Teaching program

Thermique Énergétique et Mécanique

Academic year 2023-2024

Ecole polytechnique de Nantes Université

November 13, 2023

Contents

Part I

Tables of teaching units

Semester 5 - unit *TEM 3*

Humanity Sciences - S5 — ECTS : 8

Manager : SOBOTKA Vincent

Course	Lect	Tut	PW	Proj	WP	Asst	*Coef*
• Business knowledge and entrepreneurship	3	13.5				4	*13*
• Physical education and sport 1		21				2	*13*
• Professionnal project 1	1.5	12				4.5	*13*
• Sustainable development and social responsability 1	1.5	13.5					*13*
• Project management 1	4.5		3			2	*13*
• Grammar and professional English 1		40					*35*
TOTAL	10.5	100	3	0	0	12.5	

Mathematicals Tools I — ECTS : 6

Manager : LEVY Arthur

Course	Lect	Tut	PW	Proj	WP	Asst	*Coef*
• Algorithmic		3	12				*25*
• Algebra	2.5	28.5				20	*45*
• Real and vectorial Analysis		21				10	*30*
• Experimental post-treatment	1.25	9					*1*
TOTAL	3.75	61.5	12	0	0	30	

Mechanics I — ECTS : 8

Manager : RUPIL Jérémie

Course	Lect	Tut	PW	Proj	WP	Asst	*Coef*
• Applied Mechanics, DAO	10	16	9	9		20	*40*
• General Mechanics	15	21.25	15			30	*60*
TOTAL	25	37.25	24	9	0	50	

Thermodynamic - Energetic — ECTS : 8

Manager : GADOIN Emilie

Course	Lect	Tut	PW	Proj	WP	Asst	*Coef*
• Renewable energy	20.5						*10*
• Thermodynamics : First and Second Laws, Phase Equilibrium	15	17.25	7.5			20	*45*
• Applied Thermodynamics		32	7.5			20	*45*
TOTAL	35.5	49.25	15	0	0	40	

Sum of semester

	Lect	Tut	PW	Proj	WP	Asst	ECTS
Sum	74.75	248	54	9	0	132.5	30
Face-to-face sum	385.75						

Semester 6 - unit *TEM 3*

Mathematics Tools II — ECTS : 5

Manager : LEVY Arthur

Course	Lect	Tut	PW	Proj	WP	Asst	*Coef*
• Differential and Functional Analysis	2.5	27				15	*40*
• Linear and differential systems	10	22.5		6			*60*
TOTAL	12.5	49.5	0	6	0	15	

Mechanics II — ECTS : 8

Manager : GUELED Ahmed

Course	Lect	Tut	PW	Proj	WP	Asst	*Coef*
• Fluid Mechanics	18.75	21.75	20			30	*50*
• Structural Mechanics	16.25	21.25	15			20	*50*
TOTAL	35	43	35	0	0	50	

Thermal - Energetical I — ECTS : 7

Manager : AUVITY Bruno

Course	Lect	Tut	PW	Proj	WP	Asst	*Coef*
• Conductive Heat Transfer (steady state)	15	19.75	20			30	*60*
• Thermodynamic Systems	7.5	12		9			*40*
TOTAL	22.5	31.75	20	9	0	30	

Humanity Sciences - S6 — ECTS : 8

Manager : SOBOTKA Vincent

Course	Lect	Tut	PW	Proj	WP	Asst	*Coef*
• History of organizations and Accounting business game	9	10.5	12			5	*15*
• Physical education and sport 2		21				2	*15*
• Soft skills		7.5					*15*
• Socio-economic debates and Tools for shifting		21				10	*15*
• Professional Project 2		4.5					*5*
• Grammar, Toeic and professional English 2		39	2				*35*
TOTAL	9	103.5	14	0	0	17	

Internship 3A

ECTS : 2

Manager : RUPIL Jérémie

Course	Lect	Tut	PW	Proj	WP	Asst	*Coef*
• Internship 3rd year					8		*0*
TOTAL	0	0	0	0	8	0	

Sum of semester

	Lect	Tut	PW	Proj	WP	Asst	ECTS
Sum	79	227.75	69	15	8	112	30
Face-to-face sum	390.75						

Semester 7 - unit *TEM 4*

Project I — ECTS : 4

Manager : RUPIL Jérémie

Course	Lect	Tut	PW	Proj	WP	Asst	*Coef*
• Project				40			*100*
TOTAL	0	0	0	40	0	0	

Numerical Tools — ECTS : 7

Manager : FAVENNEC Yann

Course	Lect	Tut	PW	Proj	WP	Asst	*Coef*
• Industrial simulation softwares		21					*30*
• Finite difference methods	5	13		12		15	*43*
• Finite différences	5	13.5					*27*
TOTAL	10	47.5	0	12	0	15	

Thermal - Energetical II — ECTS : 6

Manager : BELLETTRE Jérôme

Course	Lect	Tut	PW	Proj	WP	Asst	*Coef*
• Heat Convection	15	21.5	20			30	*70*
• Turbomachinery		19.5				17	*30*
TOTAL	15	41	20	0	0	47	

Humanity Sciences S7 — ECTS : 7

Manager : SOBOTKA Vincent

Course	Lect	Tut	PW	Proj	WP	Asst	*Coef*
• Business analysis	4.5	6				3	*15*
• Quality, security and environmental approaches (QSE1)		3	3				*10*
• Physical education and sport 3		21				2	*10*
• Negotiations	3	7.5				2	*10*
• Professional project 3		6				6	*10*
• Circular economy	4.5	3				6	*10*
• Professional English 3		19	2				*26.25*
1 opt ▷ Continuous Assessment (bis)							*8.75*
1 opt ▷ French as a Foreign Language for engineering students		18					*8.75*
1 opt ▷ Second foreign language - Spanish		18					*8.75*
1 opt ▷ Second foreign language - Japanese		18					*8.75*
1 opt ▷ Second foreign language - Sign language		18					*8.75*
▷ Training for Toeic		18					*8.75*
TOTAL	12	83.5	5	0	0	19	

Mechanics III — ECTS : 4

Manager : SOBOTKA Vincent

Course	Lect	Tut	PW	Proj	WP	Asst	*Coef*
• CAD		9	6				*35*
• Mechanical Vibrations	10.5	12.5	9.5			10	*65*
TOTAL	10.5	21.5	15.5	0	0	10	

Training Pathway S7 — ECTS : 2

Manager : AUVITY Bruno

Course	Lect	Tut	PW	Proj	WP	Asst	*Coef*
• 3A internship Assesment							*50*
1 opt ▷ Entrepreneurship S7				32			*50*
1 opt ▷ Transition Engineering and Interdisciplinarity S7				32			*50*
1 opt ▷ Research S7				32			*50*
1 opt ▷ Ecological and Societal Transition S7				32			*50*
TOTAL	0	0	0	32	0	0	

Sum of semester

	Lect	Tut	PW	Proj	WP	Asst	ECTS
Sum	47.5	193.5	40.5	84	0	91	30
Face-to-face sum	365.5						

Semester 8 - unit *TEM 4*

Science for Engineering — ECTS : 4

Manager : TARLET Dominique

Course	Lect	Tut	PW	Proj	WP	Asst	*Coef*
• Electrical engineering and energy		16.5	12			20	*50*
• Introduction to material science	7.5	7.5	12			24	*50*
TOTAL	7.5	24	24	0	0	44	

Thermal Radiation and Metrology — ECTS : 5

Manager : TARLET Dominique

Course	Lect	Tut	PW	Proj	WP	Asst	*Coef*
• Thermal measurement	11.25	1.5					*20*
• Thermal Radiation	16.25	16.5	20			25	*80*
TOTAL	27.5	18	20	0	0	25	

Exchanger and Convection — ECTS : 4

Manager : GUELED Ahmed

Course	Lect	Tut	PW	Proj	WP	Asst	*Coef*
• Multi-species two phase convection	13.75	12.5		6		15	*55*
• Heat Exchanger	12.5	10.5		1.5		12	*45*
TOTAL	26.25	23	0	7.5	0	27	

Humanity Sciences - S8 — ECTS : 6

Manager : SOBOTKA Vincent

Course	Lect	Tut	PW	Proj	WP	Asst	*Coef*
• Critical approaches of the firm		9				3	*13*
• Quality, security ant environmental approaches (QSE2)		6					*13*
• Physical education and sport 4		19.5				2	*13*
• Professional Project 4		12				5	*13*
• Sustainable development and social responsability 2		9				10	*13*
• Intercultural explorations		18					*17.5*
1 opt ▷ Continuous Assessment(bis)							*17.5*
1 opt ▷ French as a Foreign Language for engineering students		18					*17.5*
1 opt ▷ Second foreign language - Sign language		18					*17.5*
1 opt ▷ Second foreign language - Spanish		18					*17.5*
1 opt ▷ Second foreign language - Japanese		18					*17.5*
▷ Training for Toeic		18					*17.5*
TOTAL	0	91.5	0	0	0	20	

Internship 4A — ECTS : 5

Manager : TARLET Dominique

Course	Lect	Tut	PW	Proj	WP	Asst	*Coef*
• Internship 4th year					13		*0*
TOTAL	0	0	0	0	13	0	

Project II — ECTS : 4

Manager : RUPIL Jérémie

Course	Lect	Tut	PW	Proj	WP	Asst	*Coef*
• Project II				55			*100*
TOTAL	0	0	0	55	0	0	

Training Pathway S8 — ECTS : 2

Manager : AUVITY Bruno

Course	Lect	Tut	PW	Proj	WP	Asst	*Coef*
1 opt ▷ Entrepreneurship S8				32			*100*
1 opt ▷ Transition Engineering and Interdisciplinarity S8				32			*100*
1 opt ▷ Research S8				32			*100*
1 opt ▷ Ecological and Societal Transition S8				32			*100*
TOTAL	0	0	0	32	0	0	

Sum of semester

	Lect	Tut	PW	Proj	WP	Asst	ECTS
Sum	61.25	156.5	44	94.5	13	116	30
Face-to-face sum	356.25						

Semester 9 - unit *TEM5 : Expertise des Systèmes Energétiques*

Project

ECTS : 10

Manager : SOBOTKA Vincent

Course	Lect	Tut	PW	Proj	WP	Asst	*Coef*
• 4A Internship Assesment						20	*20*
• Industrial Project				130		75	*80*
TOTAL	0	0	0	130	0	95	

Energy Conversion System

ECTS : 8

Manager : JOSSET Christophe

Course	Lect	Tut	PW	Proj	WP	Asst	*Coef*
• Fuel, Combustion and Environnment	13.5	1				5	*14*
• Technology in Refrigerating Plant	35		4			20	*38*
• Combustion Modelling	3	7.5				7	*10*
• Modeling and Optimisation of Energy Systems	9	12				10	*21*
• Diesel Engines, Boilers	15	1.5				9	*16*
TOTAL	75.5	22	4	0	0	51	

Humanity Sciences - S9

ECTS : 4

Manager : SOBOTKA Vincent

Course		Lect	Tut	PW	Proj	WP	Asst	*Coef*
• Designing the tomorrow's management		3	6				3	*30*
• Project management 2			15				3	*35*
• People and team management			10.5				6	*30*
• Professional project 5			12				2	*5*
▷ Training for TOEIC - s9			10					*0*
TOTAL	min	3	43.5	0	0	0	14	
	max	3	53.5	0	0	0	14	

Buildings Energy

ECTS : 8

Manager : JOSSET Christophe

Course	Lect	Tut	PW	Proj	WP	Asst	*Coef*
• Ventilation and Air-conditionning Systems	9	9	4			12	*29*
• Eco-Design : Life Cycle Analysis	12					4	*9*
• Cooling and Air-Conditionning Regulation	12	1.5	4			10	*22*
• Building Energetics	31					17	*40*
TOTAL	64	10.5	8	0	0	43	

Sum of semester

		Lect	Tut	PW	Proj	WP	Asst	ECTS
Sum	min	142.5	76	12	130	0	203	30
	max	142.5	86	12	130	0	203	
Face-to-face sum		360.5 à 370.5						

Semester 9 - unit *TEM5 : Expertise en Conception Thermique*

Project

ECTS : 10

Manager : SOBOTKA Vincent

Course	Lect	Tut	PW	Proj	WP	Asst	*Coef*
• 4A Internship Assesment						20	*20*
• Industrial Project				130		75	*80*
TOTAL	0	0	0	130	0	95	

Thermical Systems

ECTS : 6

Manager : LEVY Arthur

Course	Lect	Tut	PW	Proj	WP	Asst	*Coef*
• Inverse Problems	9		6	8		8	*30*
• Heat Transfer in Processes	20	1.5	16				*50*
• Thermorheology	12	1.5				5	*20*
TOTAL	41	3	22	8	0	13	

Humanity Sciences - S9

ECTS : 4

Manager : SOBOTKA Vincent

Course		Lect	Tut	PW	Proj	WP	Asst	*Coef*
• Designing the tomorrow's management		3	6				3	*30*
• Project management 2			15				3	*35*
• People and team management			10.5				6	*30*
• Professional project 5			12				2	*5*
▷ Training for TOEIC - s9			10					*0*
TOTAL	min	3	43.5	0	0	0	14	
	max	3	53.5	0	0	0	14	

Thermomechanical design

ECTS : 5

Manager : RUPIL Jérémie

Course	Lect	Tut	PW	Proj	WP	Asst	*Coef*
• Advanced Heat Exchangers	19.5	1.5				12	*30*
• Thermal Mechanics Dimensioning	9	19.5				15	*45*
• Composites Mechanics	15	1.5				7	*25*
TOTAL	43.5	22.5	0	0	0	34	

Processes for the energy transition — ECTS : 5

Manager : PY Xavier

Course	Lect	Tut	PW	Proj	WP	Asst	*Coef*
• Solar thermal and geothermal energy	12	3	6	3			*55*
• Storage and decarbonization	7	2					*20*
• Thermal and networks	9	2					*25*
TOTAL	28	7	6	3	0	0	

Sum of semester

		Lect	Tut	PW	Proj	WP	Asst	ECTS
Sum	min	115.5	76	28	141	0	156	30
	max	115.5	86	28	141	0	156	
Face-to-face sum		360.5 à 370.5						

Semester 10 - unit *TEM 5*

End of Studies Training ECTS : 30

Manager : SOBOTKA Vincent

Course	Lect	Tut	PW	Proj	WP	Asst	*Coef*
• End of Studies Project					22		*100*
TOTAL	0	0	0	0	22	0	

Sum of semester

	Lect	Tut	PW	Proj	WP	Asst	ECTS
Sum	0	0	0	0	22	0	30
Face-to-face sum							

Part II

Sheets of courses

3A internship Assesment

Hours

Lect Tut PW Proj WP Asst

Evaluation

One evaluation : *Rapport de stage 3A*

Manager : Vincent SOBOTKA

4A Internship Assesment

Hours

Lect	Tut	PW	Proj	WP	Asst
					20

Evaluation

One evaluation : *Rapport*

Manager : Vincent SOBOTKA

Advanced Heat Exchangers

Hours

Lect	Tut	PW	Proj	WP	Asst
19.5	1.5				12

Evaluation

One evaluation : *Etude de cas*

Outline

1. Design a thermal device belonging to a primary auxiliary circuit of a nuclear power plant (RIS RES, RCV, ...) according to the AFNOR code (Pressure vessels not subject to the flame)
2. Justify or modify the proposed design with respect to functional specifications imposed
3. Decompose into sub-assemblies, taking into account the modes of development of semiproduits, best suited assembly modes and mounting constraints
4. Identify the offered materials and select others
5. Develop a plan for a technical specification for purchase each type of semi-finished products
6. Sizing using the code common thicknesses of parts subject to pressure
7. Identify openings requiring reinforcements and carry ou their sizings
8. Choose the nominal thicknesses
9. Check that the stress in the test situation is compatible with the allowable stress corresponding to the same situation,

Goals

This course aims to perform the design of a real thermal device.

Learning outcomes

Learning outcomes	N	A	M	E	O
• Designing and sizing a thermal device belonging to an auxiliary circuit primary conventional or nuclear plant	·	✓	·	·	·

Manager : Arthur LEVY

Algebra

Hours

Lect	Tut	PW	Proj	WP	Asst
2.5	28.5				20

Evaluation

3 evaluations :

- *DS2*
- *DS1*
- *CC*

Presentation

The goal of this course is to master matrix representation and linear system solving which are necessary to model mechanical, thermal and energetic systems.

Outline

Reminders and additional informations on linear algebra

Vector spaces, linear applications, Multilinear Applications, matrices, determinants, eigenvectors and eigenvalues.

Bibliography

Toute l'algèbre du premier cycle. Jean-Pierre Escofier. Dunod 2002

Cours de mathématiques : 1 : Algèbre. Ramis Edmond, Deschamps Claude, Odoux Jacques. Dunod 2017

http://exo7.emath.fr/

https://emaths.education

Learning outcomes

Learning outcomes	N	A	M	E	O
• Use mathematical tools to model and solve a problem	·	✓	·	·	·
• Use numerical methods to simulate a complex problem	✓	·	·	·	·

Manager : Arthur LEVY

Algorithmic

Hours

Lect	Tut	PW	Proj	WP	Asst
	3	12			

Evaluation

One evaluation : *TP*

Presentation

The lessons are often a first encounter with computer sciences, in their fundamental aspects. First, the lessons are presenting the basic concepts of computable numbers, and the use of a microprocessor as well. Then, algorithms and the possible answers to a given problem are taught, along with the available tools (such as loops). Problem modelisation, and the sequential behavior of algorithms are at the core of the theoretical classes. They are completed by training in algorithms, and by computer lessons with a real programming language.

Outline

Notions of Algorithms and Modelling
- Information representation and numerical errors
- Elements of Information, simple Objects and Structured Objects
- Elementary actions & notion of algorithm
- Structured actions, alternatives. Selective iterative
- Down analysis,
- Actions set, Functions, Procedures
- Data structure, File Pile, Tree and Graph
- Development & Evaluation of algorithms

Goals

The teaching Algorithmic module aims to build a methodology to analyze a problem and develop appropriate resolution schemes based on a finite set of structured objects and actions. These reasoning processes are essential in a engineering approach to efficiently respond to offers subject to precise specifications

Bibliography

- D.Knuth, "The art of computer programming - Vol. 1 : Fundamental algorithms"; Eds. Addison / Wesley, 2003.
- J. Maysonnave ; « Introduction à l'algorithmique générale et numérique » ; Masson
- J. Courtin? I. Kowarski ; « Initiation à l'algorithmique et aux structures de données » ; Dunod
- D. Beauquier, J. Berstel, P. Chrétienne ; « Eléments d'algorithmique » ; Masson
- Christophe Darmangeat ; « Algorithmique et programmation pour non-matheux » ; Université Paris 7, www.pise.info/algo/
- Claude Delannoy ; « Le livre du C premier langage » ; Eyrolles, 2001

Prerequisites

The lessons consider that students are beginners without knowledge or experience neither in algorithms, nor in computer programming.

Learning outcomes

Learning outcomes	N	A	M	E	O
• Build a rational and structured methodology to provide solutions to engineering problems using algorithmic techniques	·	·	✓	·	·
• Modeling, and formulation a concrete problem: from the mathematical representation to the resolution in computer sciences	·	✓	·	·	·
• Apply methodologies to program simple algorithms in C language, using data structures and procedures needed to achieve digital projects in subsequent semesters	·	·	✓	·	·

Manager : Dominique TARLET

Applied Mechanics, DAO

Hours

Lect	Tut	PW	Proj	WP	Asst
10	16	9	9		20

Evaluation

3 evaluations :

- *1 DS*
- *CR*
- *CC*

Presentation

Through the study of different mechanical systems: reduction gear, gear pump, axial piston pump, motor, compressor, this course deals with the practical aspects of mechanics such as the reading of the assembling plan, the manipulation of CAD models, the choice of technical components (plain bearings, screws, gears, ...) in manufacturer's catalogs and the design of simple assembly solutions.

Outline

Course part:
Reading and drawing of industrial plans
Functional tolerancing of industrial plans
Manufacturing processes
"Simplified" design process
Practical part:
3D CAD tutorial (CATIA V5)
Exercices part:
Studies of technical plans, technological solutions and guided exercises CAD:
-marine reduction gear
-compressor
-axial piston pump
-thermal motor
Micro project part:
Design of a technical solution under CATIA V5 in connection with a practical problem in the thermal or energetic field.

Goals

-be able to read a definition plan or an assembling plan of a mechanical system
- be able to use CATIA V5 in order to:
draw a part
make an assembly
make a plan of a part or an assembly
propose a simple tolerancing of a part
-be able to design a technical solution in the form of an assembly of several parts.

Bibliography

Quatremer, R., et al. "Précis de Construction Mécanique, Tome 1, Projets-études, composants, normalisation." (2001).

Fanchon, Jean-Louis. Guide des sciences et technologies industrielles. Nathan, 2013.

Esnault, Francis. Construction mécanique. Dunod, 1993.

Aublin, Michel. "Systèmes mécaniques." (1992).

Prerequisites

None

Learning outcomes

Learning outcomes	N	A	M	E	O
• Be able to use CATIA V5 to: draw a part, make an assembly, draw a part plan.	·	·	✓	·	·
• Know how to read a plan of a classic mechanical system (reduction gear, motor, pump, ...)	·	·	✓	·	·
• To be able to design a mechanical assembly in order to answer a technical problem related to the field of thermal or energetics.	·	·	✓	·	·

Manager : Jérémie RUPIL

Applied Thermodynamics

Hours

Lect	Tut	PW	Proj	WP	Asst
	32	7.5			20

Evaluation

3 evaluations :

- *1 DS*
- *TP*
- *CC*

Outline

1. Thermodynamic diagrams
2. Receiving machines
3. Generating machines of work (engines)
4. Elementary transformations used in the machines
5. General information on the machines studied in this course
6. Complement: Thermodynamics of the humid air (Psychrometry)

Goals

The objective of the course is to bring a basic knowledge in the heat engines di-thermal baths: Which are the principal machines? On which principles technique and thermodynamics do function they? How to calculate their output or coefficient of performance? How to trace and exploit their cycle of operation in thermodynamic diagrams?

Bibliography

Lucien Borel, Din Lan Nguyen ; « Thermodynamique et énergétique, Problèmes résolus et exercices » ; Presses polytechniques romandes

R. Kling ; « Thermodynamique générale et applications » ; Editions Technip

R. Giquel ; « http ://www.thermoptim.org/sections/bases-thermodynamique/notions-fondamentales

Prerequisites

Concepts of general thermodynamics: first and second principles.

Learning outcomes

Learning outcomes	N	A	M	E	O
• To know the principal heat engines dithermes	·	✓	·	·	·
• To know the thermodynamic principle of operation of the dithermal machines and to know to trace their cycle in an unspecified diagram	·	✓	·	·	·
• To know to exploit a cycle of dithermal machine to calculate the performances of them	·	✓	·	·	·
• To know and use the thermodynamic properties of the humid air (psychrometry)	·	✓	·	·	·

Manager : Bruno AUVITY

Building Energetics

Hours

Lect	Tut	PW	Proj	WP	Asst
31					17

Evaluation

One evaluation : *CR*

Outline

1. human thermal comfort
   2. energy building legislation
   3. Heat and mass (air & water vapour) balance of a local
   4. heating loads
   5. cooling loads
   6. building application 7. software presentation and start up
   8. project: energy consumption analysis and optimization of a building

Goals

This course is an application of heat transfer and energy knowledge in the fields of building energy. The estimation of the heat and mass balance of a building interacting with its environment and its occupants is the starting point of design of the HVAC facility. Moreover, since 2000 with the so called RT2000, the French energy legislation for energy building efficiency improved the target of building energy consumption. At the end of this course, the student will be able to estimate the energy requirements of a building and its compliance with the current legislation. The appplication is done through a project to study the energy legislation aspect and dynamic thermal simulation of a building with a professional software (CYPE) to highlight the inertial effects and the influence of various design choices, including: control, taking account of the environment (masking effect). . . and to quantify the influence of different elements (control, orientation, glazing, insulation, ventilation....) on the annual energy performance of a building.

Bibliography

- Hermann Recknagel, Eberhard Sprenger, E.-R. Schramek ; « Le Recknagel - Manuel pratique du génie climatique » ; PYC Editions, 1995
- COSTIC; « Le calcul simplifié des charges de climatisation : Méthode COSTIC » ; SEDIT, 2004
- COSTIC; « Amélioration énergétique des bâtiments existants : les bonnes solutions » ; SEDIT, 2004
- P Dal Zotto, J-M Larre, A Merlet, L Picau ; « Mémotech Génie Energétique » ; Casteilla, 2003
- Roger CADIERGUES; « MEMOCLIM BASE 2006.1 » ; SEDIT, 2006
- Claude Gillet, Gilles Cambillau, Bernard Sesolis ; « Comprendre et utiliser la Réglementation Thermique 2000 » ; Delagrave, 2005
- CSTB; « Guide réglementaire de la Réglementation Thermique 2012 » ; CSTB, 2012
- Salem Farkh et Thierry Be ; « Les ponts thermiques dans le bâtiment - Mieux les connaître pour mieux les traiter » ; CSTB, 2006

Prerequisites

-heat transfer (conduction, convection, radiation)
- analogic & numerical PID regulation

Learning outcomes

Learning outcomes	N	A	M	E	O
• to characterize the parameters influencing the thermal comfort	·	·	✓	·	·
• to establish the thermal and mass balances of a building	·	·	✓	·	·
• to know the energy building legislation	·	·	✓	·	·

Manager : Christophe JOSSET

Business analysis

Hours

Lect	Tut	PW	Proj	WP	Asst
4.5	6				3

Evaluation

One evaluation : *Etude de cas*

Bibliography

- A de Baynast, J Lendrevie, J Levy; Mercator"; Dunod. Dernières éditions
- F Canart ; Management de la qualité ; Gualino L Extenso Editions
- Henri Mintzberg, Structure et dynamique des organisations (Éd. d'organisation)
- M.Crozier ; A quoi sert la sociologie des organisations (Éd. Seli Arslan)
- S. Robbins, D. DeCenzo, M. Coulter ; Management, l'essentiel des concepts et des pratiques (9ème éd) Ed. Pearson
- https://www.l-expert-comptable.com/dossiers/evaluer-l-entreprise-reprendre-grace-l-analyse-economique.html
- https://www.fao.org/capacity-development/resources/practical-tools/analyse-organizational-performance/fr/

Learning outcomes

Learning outcomes	N	A	M	E	O
• TPN-1	·	✓	·	·	·
• TPN-4	✓	·	·	·	·

Manager : Gwenael THOREL

Business knowledge and entrepreneurship

Hours

Lect	Tut	PW	Proj	WP	Asst
3	13.5				4

Evaluation

One evaluation : *Etude de cas*

Bibliography

? Cyr, A. (2009). Les représentations entrepreneuriales, sous la direction de Louis Jacques Filion et Christian Bourion, Paris, Eska, 2008, 262 p. Revue internationale PME Économie et gestion de la petite et moyenne entreprise, 22(3-4), 174-176.

? Henri Mintzberg, Structure et dynamique des organisations (Éd. d'organisation)

? http://www.laurentdehouck.fr/enseignements/histoire-des-idees-sur-les-organisations/

? M. Bidan et Y. Livian (2022), les grands auteurs aux frontières du management (Editions EMS)

? M.Crozier ; A quoi sert la sociologie des organisations (Éd. Seli Arslan)

? Osterwalder, A., Pigneur, Y., & Tucci, C. L. (2005). Clarifying business models: Origins, present, and future of the concept. Communications of the association for Information Systems, 16(1), 1.

? Ramadani, V. (2009). Business angels: who they really are. Strategic Change: Briefings in Entrepreneurial Finance, 18(7?8), 249-258.

? S. Robbins, D. DeCenzo, M. Coulter ; Management, l'essentiel des concepts et des pratiques Ed. Pearson.

? Sarasvathy, S. D. (2001). Causation and effectuation: Toward a theoretical shift from economic inevitability to entrepreneurial contingency. Academy of management Review, 26(2), 243-263.

Learning outcomes

Learning outcomes	N	A	M	E	O
• TPN-1	✓	·	·	·	·
• TPN-4	✓	·	·	·	·
• TPN-6	✓	·	·	·	·

Manager : Luc OILI

CAD

Hours

Lect	Tut	PW	Proj	WP	Asst
	9	6			

Evaluation

2 evaluations :

- *CR*
- *DS*

Presentation

This CAD course allows, thanks to the use of INVENTOR software, to return to the work carried out during previous semesters (S5 and S6) on mechanical systems (type pump, reducer, compressor, motor, ...) and on solid mechanics theory but only through numerical studies.

Outline

1. sizing in mechanical engineering :
   - drive shafts, gears, bearings, components of joints, ...
   2. pumps, compressors, reducers : numerical simulation
   3. mini-project :
   - sizing a mechanism or a mechanical component

Goals

To be faced with the problems of mechanical conception and mechanical engineering,
to be initiated into study report writings (robust design, choice of mechanical components, sizing of mechanical parts,...).

Bibliography

- F. Esnault ; « Construction mécanique : principes et applications (3 tomes) » ; Dunod,

Prerequisites

Mechanics of rigid bodies
Strength of materials

Learning outcomes

Learning outcomes	N	A	M	E	O
• To size drive shafts, gears, bearings, components of joints, ...	·	·	✓	·	·
To implement optimization					
• To modelize a mechanism with Inventor and Catia	·	·	✓	·	·
To check with numerical simulation					
• To write a study report	·	·	✓	·	·

Manager : Jérémie RUPIL

Circular economy

Hours

Lect	Tut	PW	Proj	WP	Asst
4.5	3				6

Evaluation

One evaluation : *Diagnostic*

Bibliography

- AUREZ Vincent, GEORGEAULT Laurent, Economie circulaire, de Boeck
- Cf bibliographie donnée pendant le cours

Learning outcomes

Learning outcomes	N	A	M	E	O
• TPN-3	✓	·	·	·	·

Manager : Chrystèle GONCALVES

Combustion Modelling

Hours

Lect	Tut	PW	Proj	WP	Asst
3	7.5				7

Evaluation

One evaluation : *SO*

Outline

1. Definitions
   2. "Turbulence - Chemistry" Interactions
   - Damköler number
   - Combustion models (Eddy Break Up, Eddy Dissipation Concept . . .)
   3. "two-pahse" Combustion « di-phasique »
   - Atomisation
   - Droplets vaporisation and combustion
   4. Applications
   "numerical simulations of turbulent reacting flows"

Goals

The aim of this course is to study the basic physical mechanisms that are present within a flame. These knowledge are then used to perform numerical simulations of turbulent reacting flows and pollutant emissions in combustion chambers.

Bibliography

- L. Vervish, D. Veynante, J.P.A.J. van Beek, ; « Turbulent combustion, Lecture series 2005-02 » ; Ed. von Karman Institute for Fluid Mechanic, Belgique, 2005

Prerequisites

- Convection (Laminair and two-phases)
  - Convection and Turbulence
  - Fluid mechanics
  - Thermodynamics

Learning outcomes

Learning outcomes	N	A	M	E	O
• Performing a flame identification	·	·	✓	·	·
• Chosing a combustion model	·	·	·	✓	·
• Performing a numerical simulation of a turbulent reacting flow	·	✓	·	·	·

Manager : Jérôme BELLETTRE

Composites Mechanics

Hours

Lect	Tut	PW	Proj	WP	Asst
15	1.5				7

Evaluation

2 evaluations :

- *1 DS*
- *TP*

Outline

1. Mechanical effects of fiber reinforcement
2. Anisotropic constitutive equations in linear elasticity
3. Mechanical behavior of laminate composites : simplified Kirschhoff-Love theory, integrated stiffness matrices
4. Failure mechanisms and criteria
5. Application examples

Goals

Provide the basic knowledge on mechanical effects of fiber reinforcement, constitutive modeling for an anisotropic behavior in linear elasticity. Understand the effects of plys organisation in laminate composites, especially the coupling between tensile and flexion phenomena. Be able to design the architecture of a laminate composite submitted to a given loading.

Bibliography

Matériaux Composites, J-M Berthelot, Ed. Tec & Doc, Lavoisier, Paris, 2005. Matériaux Composites, F. Gay, Hermès Science Publications, 2005. Généralités sur les matériaux composites, L. Gornet, Ecole Centrale de Nantes, 2008.

Prerequisites

Basic knowledge in continuum mechanics and mechanics of materials (stress, strain, constitutive equations)

Learning outcomes

Learning outcomes	N	A	M	E	O
• Knowledge of basic principles of the effects of fiber reinforcement on the mechnical behaviour	·	·	✓	·	·
• Manage the notions of anisotropic elasticity and the consequencies of material symmetries on the mechnical behaviour of composites	·	·	✓	·	·
• Understand the principle of composite plates theory	·	✓	·	·	·
• Design and dimension layered composites for a given mechanical loading	·	✓	·	·	·

Manager : Steven LE CORRE

Conductive Heat Transfer (steady state)

Hours

Lect	Tut	PW	Proj	WP	Asst
15	19.75	20			30

Evaluation

4 evaluations :

- *TP*
- *DS1*
- *DS2*
- *CC*

Outline

1. Fourier's law, the thermal gradient, thermal conductivity
2. Equated a conduction problem
- First law of thermodynamics and heat equation
- The boundaries and initial conditions
3. Heat Trabsfer in Seady State
- Concept of thermal resistances of wall, surface, contact
- Approximation of the rod
- 2D and 3D problems in steady state : separation of variables method
- Contriction macro-phenomena: thermal resistance of constriction
4. Unsteady regimes
5 Approximation of semi-infinite media
- Solving transient conduction through the transformation of Laplace
6. Other methods of resolution (Duhamel theorem)
- The theorem of Duhamel
7- The periodic regime 8. THEMES OF WORK DIRECTED
- The Fourier law
- Steady, concept of thermal resistance
- Mathematical formulation of conduction problems, insulation thickness criticism, temperature-dependent conductivity, the fins
- Conduction steady two-dimensional
- The thermal regime Transition systems blocks (Figure capacitive), the method of separation variables
- Transitional arrangements for the Laplace transform; approximation semiinfinis environments
- The theorem of Duhamel
- The periodic regime established
8. THEMES OF WORK DIRECTED
- Fourier Law, transfer in Steady state, concept of thermal resistance
- Mathematical formulation of conduction problems, insulation thickness criticism, temperature-dependent conductivity, the fins
- Conduction steady two-dimensional
- Transient thermal regime: lumped systems, Fourier method
- Laplace transform; approximation of semi-infinite medium, Duhamel theorem
- The periodic regime established
9. THEMES OF PRACTICE WORKS
- Heat transfer through a single wall or multilayer partition in steady state
- Measurement of thermal conductivity (method of the thermal barrier)

- Error in temperature measurement by thermocouple
- Thermal constriction phenomenon of thermal contact resistance
- Measurement of thermal diffusivity by the flash method
- Measurement of heat flow by inertial sensor

Goals

The purpose of the transfer by conduction is the prediction of heat flux transmitted. At the end of the course, students should be able to determine a temperature field in basic geometry, regardless of the thermal regime. It can then deduce the components of heat flux transmitted vector. This knowledge is a prerequisite to the question how to stimulate or restrict the transfer to satisfy the conditions to achieve in a given application.

Bibliography

- A. B. De Vriendt ; « La transmission de la chaleur (tome 1, 2) » ; Gäetan Morin Editeur, 1982
- J. F. Sacadura ; « Initiation aux transferts thermiques » ; Lavoisier (Tec & Doc), 1977
- F. P. Incropera and D. P.Dewitt ; « Fundamentals of Heat and Mass Transfer » ; J. Wiley edition, 4th edition, 1988
- J. P. Holman ; « Heat Transfer » ; Mc Graw Hill, S. I. Metric Edition, 1989
- M. N. Ozisik ; « Heat Transfer, a Basic Approach » ; Mc Graw Hill, 1985
- M. N. Ozisik ; « Heat Conduction, » ; J. Wiley edition? 1980
- M. N. Ozisik ; « Boundary Value problems of Heat Conduction » ; Dover Publication, 1976
- V. P. Arpaci ; « Conduction Heat Transfer » ; Addison Wesley Edition, 1956
- E. R. G. Eckert and R. M. Drak; « Analysis of heat and Mass transfer » ; Mc Graw Hill, 1959
- Carslaw and Jaegger ; « Conduction in Solids » ; Oxford Publication, 1959

Prerequisites

- Fonctionnal and différential Analysis

Learning outcomes

Learning outcomes	N	A	M	E	O
• Know mathematical formulation of heat conduction problem (heat equation and boundaries conditions)	·	·	·	✓	·
• able to solve a problem regardless of the conduction thermal regime and the extent of the studied domain,	·	·	✓	·	·
• Able to analyze the solutions obtained: contribution of the different sources, chronology of thermal events, superposition	·	✓	·	·	·
• able to use the solution of the heat conduction problem for sizing system organ	·	✓	·	·	·

Manager : Nicolas BAUDIN

Continuous Assessment (bis)

Hours

Lect Tut PW Proj WP Asst

Evaluation

One evaluation : *CC*

Continuous Assessment(bis)

Hours

Lect Tut PW Proj WP Asst

Evaluation

One evaluation : *CC*

Cooling and Air-Conditionning Regulation

Hours

Lect	Tut	PW	Proj	WP	Asst
12	1.5	4			10

Evaluation

One evaluation : *1 DS*

Outline

1. Terminology
   2. Modes of regulation of expression
   3. Modes of regulation
   4. Material available now
   5. basis of procedures and controls
   6. Diagrams of facilities and standard systems (production & use)
   7. Applications

   Control of production units refrigeration
   Regulation of heat production units
   Control of air conditioning systems
   Regulation of heat transfer circuits (cooling, heating)

Goals

The student will be able to understand technical documents describing an HVAC facility, to check the dimensioning and the control of this system. he could also modify the installation if necessary and write new explanatory documents.

Bibliography

- René CYSSAU et un groupe de 12 spécialistes de l'acr ; « Manuel de la régulation et de la gestion de l'énergie » ; PYC édition, 1986
- Jacques BOUTELOUP, Michel LEGUAY et Jean LIGEN; « Production de chaud et de froid » ; Les éditions parisiennes, 1997
- P.J. RAPIN et P. JACQUARD; « Installations frigorifiques (tome 2) » ; PYC édition
- « Publications des entreprises de la profession »

Prerequisites

- Electrical engineering
  - fluid mecanics
  - Thermodynamic systems
  - Applied Thermodynamic
  -General Thermodynamic

Learning outcomes

Learning outcomes	N	A	M	E	O
• to know the components for controlling fluidic facilities	·	·	✓	·	·
• to know the patterns of control for fluid facilities	·	·	✓	·	·

Manager : Christophe JOSSET

Critical approaches of the firm

Hours

Lect	Tut	PW	Proj	WP	Asst
	9				3

Evaluation

One evaluation : *Exposé*

Bibliography

- Carney, B. M., & Getz, I. (2016). Freedom, Inc: How Corporate Liberation Unleashes Employee Potential and Business Performance. International Creative Management.

- Detchessahar, M. (2019). L'entreprise délibérée: refonder le management par le dialogue. Nouvelle cité.

- Dujarier, M.-A. (2017). Le management désincarné: enquête sur les nouveaux cadres du travail. La découverte.

- Gomez, P.-Y. (2013). Le travail invisible: enquête sur une disparition. Paris: F. Bourin.

- Les statuts juridiques de l'entreprise (Dessine-moi l'éco)

- Rendre le travail visible : la solution pour sortir de la crise (Dessine moi l'éco)

Learning outcomes

Learning outcomes	N	A	M	E	O
• TPN-1	✓	·	·	·	·
• TPN-3	✓	·	·	·	·
• TPN-4	✓	·	·	·	·
• TPN-6	✓	·	·	·	·

Manager : Roland BESSENAY

Designing the tomorrow's management

Hours

Lect	Tut	PW	Proj	WP	Asst
3	6				3

Evaluation

One evaluation : *Grille d'évaluation*

Bibliography

Partie don :

L'entreprise une affaire de don (Collectif, 2016)

Recevoir pour donner (Collectif, 2016)

Partie Jeux sérieux :

Theory of Fun for Game Design, Raph Koster, O'Reilly Media; Second edition, ISBN ? 978-1449363215

Learning outcomes

Learning outcomes	N	A	M	E	O
• TPN-1	·	·	✓	·	·
• TPN-2	·	·	✓	·	·
• TPN-3	·	·	✓	·	·
• TPN-4	·	·	✓	·	·
• TPN-5	·	·	✓	·	·

Manager : Roland BESSENAY

Diesel Engines, Boilers

Hours

Lect	Tut	PW	Proj	WP	Asst
15	1.5				9

Evaluation

One evaluation : *1 DS*

Outline

1. Diesel engines: thermodynamic cycles and technological aspects,
2. Industrial boilers and turbines: fluid circulation, heat exchangers, regulation.

Goals

This course delivers knowledges regarding Diesel engines, industrial boilers and their specific constraints.

Bibliography

- R. BRUN; « Science et technique du moteur Diesel industriel et de transports » ; éditions Technip de l'Institut Francais du Pétrole
- Techniques de l'Ingénieur
- « Cours chaudières des marines Marchande et Militaire » ; Techniques de l'Ingénieur
- Documentations fournisseurs : SEMT Pielstick,MAN-Sulzer, Babcock, Foster-Wheeler, Stein-Industrie. . .

Prerequisites

Heat Conduction
Heat Convection
Applied mechanics
Thermodynamics

Learning outcomes

Learning outcomes	N	A	M	E	O
• knowing characteristics regarding energy production and pollutant emissions of engines, boilers and turbines	·	✓	·	·	·
• knowing specific constraint of these machines	·	✓	·	·	·

Manager : Jérôme BELLETTRE

Differential and Functional Analysis

Hours

Lect	Tut	PW	Proj	WP	Asst
2.5	27				15

Evaluation

3 evaluations :

- *DS1*
- *DS2*
- *CC*

Presentation

The goal is to introduce signal treatment tools as well as systematic analytical methods for resolution of differential equations. The introduction of the distribution theory will open the mind of the student.

Outline

Dirac distribution and the concept of functional, Convolution product of functions and distributions, Fourier transform of functions and distributions, Fourier series, Laplace transform of functions and distributions. integral transform applications.

Goals

Introduce the Dirac impulsion rigorously.
Master the convolution product.
Use the main integral transform.

Bibliography

- L. Schwartz ; « Cours d'analyse » ; Hermann
- R. Petit ; « L'outil mathématique » ; Dunod
- R. Roddier ; « Distributions et transformations de Fourier » ; Ediscience
- N. Boccara ; « Fonctions analytiques » ; Ellipses
- J. Dixmier ; « Cours de Mathématiques » ; Gauthiers-Villars
- P. Benoist-Gueutal et M. Courbage ; « Mathématiques pour la physique » ; Eyrolles
- G. Gasquet et P. Witomski ; « Analyse de Fourier et applications » ; Masson

Learning outcomes

Learning outcomes	N	A	M	E	O
• Know and understand the basic tools for functional analysis (distribution, convolution equation and integral transforms) and differential (especially solving PDEs of Physics)	·	·	✓	·	·
• Application of these tools to the phenomena of conduction and transport of matter and energy, to the problems of signal processing	·	·	✓	·	·

Manager : Arthur LEVY

Eco-Design : Life Cycle Analysis

Hours

Lect	Tut	PW	Proj	WP	Asst
12					4

Goals

The aim of this lecture is to educate future engineers to the eco-design, with a particular focus on the construction sector (from structure to technical equipments). Once presented the analysis of the life cycle (principle, methodology and limitations) this will be applied to specific examples of construction (structural materials, insulation ...) to illustrate how this different analysis indicators (energy, waste, water ...) will be taking into account in the final choice.

a focus on the new RE2020 will be done.

Bibliography

- Bruno Peuportier ; « Eco conception des bâtiments » ; presse des mines, 2023

-"règlementation environnementale RE2020"

Learning outcomes

Learning outcomes	N	A	M	E	O
• to know the tools involved into the cycle life analysis	✓	·	·	·	·
• to know the main criteria and processus of the eco conception approach	✓	·	·	·	·

Manager : Christophe JOSSET

Ecological and Societal Transition S7

Hours

Lect	Tut	PW	Proj	WP	Asst
			32		

Evaluation

One evaluation : *Evaluation*

Manager : Emilie GADOIN

Ecological and Societal Transition S8

Hours

Lect	Tut	PW	Proj	WP	Asst
			32		

Evaluation

One evaluation : *Evaluation*

Manager : Emilie GADOIN

Electrical engineering and energy

Hours

Lect	Tut	PW	Proj	WP	Asst
	16.5	12			20

Evaluation

2 evaluations :

- *1 DS*
- *CR TP*

Outline

1. Power transmission grid - Single or three-phase supplies - Electrical safety devices
2. Magnetic circuits ans single or three phase transformers
3. Alternators
4. DC motors and DC generators - Speed control systems
5. AC motors - Variable speed systems

Laboratory : Single phase transformer : no load, short circuit and on load tests - Electrical power measurements using three phases supplies: star and delta connection - DC motor and generator: torque, energy conversion efficiency, speed control - Asynchronous motor : torque, slip, variable speed system with frequency driver

Goals

Give the basic knowledge onto electrical engineering: from power transmission grid to the description and use of electrical machines. This course is given in the form of lectures combined with tutorials to allow a strong interaction between students and professor. Laboratory work is an illustration very close to all the notions seen during the course.

Bibliography

- J.L. COQUERELLE; « Génie Electrique du réseau au convertisseur » ; Technip
- I. BERKES; « Les Bases de l'Electrotechnique » ; Vuibert
- G. SEGUIER, F. NOBLET; « Electrotechnique Industrielle » ; Lavoisier
- T. WILDI; « Electrotechnique » ; Deboeck, Université
- MERAT; « Electrotechnique » ; Nathan

Learning outcomes

Learning outcomes	N	A	M	E	O
• Be able to evaluate the electric behavior of electrical load connected to single-phase or three-phase electrical supplies	·	✓	·	·	·
• Be able to modelize the functioning of transformers, alternators and motors	·	✓	·	·	·
• Be able to implement electrical measurements on devices and machines connected to single and three phases electrical supplies	·	✓	·	·	·
• Have a knowledge of the basic elements of electrical safety	·	·	✓	·	·

Manager : Pierre-Yves TESSIER

End of Studies Project

Hours

Lect	Tut	PW	Proj	WP	Asst
				22	

Evaluation

One evaluation : *Rapport+Soutenance*

Learning outcomes

Learning outcomes	N	A	M	E	O
• -	·	✓	·	·	·
• -	·	✓	·	·	·

Manager : Vincent SOBOTKA

Entrepreneurship S7

Hours

Lect	Tut	PW	Proj	WP	Asst
			32		

Evaluation

One evaluation : *Evaluation*

Manager : John KINGSTON

Entrepreneurship S8

Hours

Lect	Tut	PW	Proj	WP	Asst
			32		

Evaluation

One evaluation : *Evaluation*

Manager : John KINGSTON

Experimental post-treatment

Hours

Lect	Tut	PW	Proj	WP	Asst
1.25	9				

Presentation

Based on experimental data, post-treatment skills (such as calculation, editing proper graphs, criteria indexing etc.) are taught through practice of open-source software hosted at Polytech servers (Jupyter / Python).

Outline

- lecture : thermal measurement devices
  - TP1 : Post-treatment of data "Stirling engine".
  - TP2 : Data for treatment, fit, graphs, indexing / slicing.
  - TP3 : multi-dimensional data.

Goals

- ability to transmit experimental data to Python format, calculation / modification, criterion indexing / slicing.
  - editing graphs of professional level (postscript) including labels of axes, units, markers (symbols) and shades of colors, line styles etc.
  - fitting experimental data to theoretical formulae (optimisation, linear regression etc.)

Prerequisites

Basic PYTHON skills.

Learning outcomes

Learning outcomes	N	A	M	E	O
• learn how to use a new PYTHON command.	·	·	✓	·	·
• To edit high-quality graphs (post-script) for reports, etc.	·	·	✓	·	·
• To fit experimental data to theoretical formula.	·	·	✓	·	·

Manager : Dominique TARLET

Finite difference methods

Hours

Lect	Tut	PW	Proj	WP	Asst
5	13		12		15

Evaluation

2 evaluations :

- *1 DS*
- *CRSO*

Outline

1. Finite Differences: Discretisation and Taylor developpements, consistancy and stability with explicit and implicit time-integration schemes, centered and forward/backward decentered schemes. Integration of boundary conditions. Application on diffusion problems, advection, and convection-diffusion problems.

2. Finite elements: Variational formulations, The first-order basis functions, Comparison with the finite differences methods and with the finite volumes methods. Applications on physical problems under the Freefem++ environment: transient diffusion problems, coupled and non-linear problems.

Goals

This course which is in the field of scientific computation gives basic numerical methods and tools for solving physical problems governed by partial differential equations. After finite difference methods, finite element methods are here taught.

Bibliography

- A. Quarteroni, R. Sacco, F. Saleri ; « Méthodes numériques pour le calcul scientifique » ; Springer, 2000
- I. Danaila, F. Hecht, O. Pironneau ; « Simulation numérique en C++ » ; Dunod, 2003
- G. Allaire ; « Analyse numérique et optimisation » ; Les éditions de l'école polytechnique, 2005

Learning outcomes

Learning outcomes	N	A	M	E	O
• Know and understand the basic discretisation methods for the solution of physical problems governed by partial differential equations	·	·	✓	·	·
• Choose pertinently the numerical parameters in order to get a convergence towards the solution	·	·	✓	·	·
• Use software environments dealing with variational formulations	·	✓	·	·	·

Manager : Yann FAVENNEC

Finite différences

Hours

Lect	Tut	PW	Proj	WP	Asst
5	13.5				

Evaluation

2 evaluations :

- *1 DS*
- *CRSO*

Outline

introduction on scientific computation and histotical recall.
Taylor development and approximation of differential calculus
1D diffusion-reaction problem with Dirichlet BC.
Approximation errors.
Extension to 2D.

Goals

This course which is in the field of scientific computation gives basic numerical methods and tools for solving physical problems governed by partial differential equations. Before teaching finite element methods, finite difference methods are here taught.

Fluid Mechanics

Hours

Lect	Tut	PW	Proj	WP	Asst
18.75	21.75	20			30

Evaluation

3 evaluations :

- *TP*
- *DS1*
- *DS2*

Outline

1. Introduction 2. Fluid hydrostatics, 3. Integral Relations for a Control Volume, 4. Differential relations for a Fluid particle, 5. Dimensional Analysis and Similarity, 6. Viscous Flow in Ducts, 7. Boundary-Layer Flows, 8. Potential Flows

Goals

This course is designed as a basic course in fluid mechanics for Engineers. Many applications are considered in order to illustrate physical phenomena. The basic concepts are established and used in order to prepare the background for convection fundamentals.

Bibliography

- Franck WHITE; « Fluid Mechanics » ; MC Graw Hill, 2003
- Etienne GUYON; « Hydrodynamique Physique » ; EDP Sciences, 2001
- Hermann SCHLICHTING; « Boundary layer theory » ; MC Graw Hill, 1979

Prerequisites

Thermodynamics, Continuum Mechanics, Maths for Engineers.

Learning outcomes

Learning outcomes	N	A	M	E	O
• Understand the fundamentals of Fluid Mechanics	·	·	✓	·	·
• Disign of hydrolic and aerodynamic Equipments	·	✓	·	·	·
• Calculate and measure the forces excerted by a flow on a body/surface	·	·	✓	·	·
• Calculate and measure the flow velocity and pressure fields	·	·	✓	·	·

Manager : Ahmed GUELED

French as a Foreign Language for engineering students

Hours

Lect	Tut	PW	Proj	WP	Asst
	18				

Evaluation

One evaluation : *CC*

French as a Foreign Language for engineering students

Hours

Lect	Tut	PW	Proj	WP	Asst
	18				

Evaluation

One evaluation : *CC*

Fuel, Combustion and Environnment

Hours

Lect	Tut	PW	Proj	WP	Asst
13.5	1				5

Evaluation

One evaluation : *1 DS*

Outline

1. The fuels
   2. The combustion
   3. The pollutant emissions and environmental legislation
   4. Application exercices
   5. Visit of an electrical plant

Goals

The objective is to present the different fossile fuels and their charcteritics in the field of combustion in electrical plants. Main pollutants are identified,their quantity predicted and the taxe calculated.

Bibliography

- www.eper.cec.eu.int

Prerequisites

Thermodynamics

Learning outcomes

Learning outcomes	N	A	M	E	O
• knowing the different fuels and their characteristics	·	·	✓	·	·
• knowing the polluant emissions law	·	✓	·	·	·
• calculating the taxes regarding pollutant emissions	·	✓	·	·	·

Manager : Jérôme BELLETTRE

General Mechanics

Hours

Lect	Tut	PW	Proj	WP	Asst
15	21.25	15			30

Evaluation

4 evaluations :

- *TP*
- *DS1*
- *DS2*
- *CC*

Presentation

This course presents the main principles of Newtonian indeformable solid mechanics (Newton's law of motion, principle of least action, Lagrangian mechanics) as well as simple problem solving methods.

Outline

1. Introduction (modeling and fundamental assumptions)
2. Parameters settings for solid location
3. Modeling solide motion (Kinematics)
4. Mechanical action modelling
5. Physical behaviour law : first Newton's law of motion
6. Mass center, moments of inertia
7. Kinetics/Dynamics and second Newton's law of motion
8. Energy methods
9. Lagrange's equations

Goals

Modelling and solving methods for mechanical problems of rigid bodies ;
Calculation of forces, velocities, accelerations, energies ;
Motion equations calculation.

Bibliography

- J.C. Bône ; « Mécanique générale » ; Dunod, 1984
- McLean & Nelson ; « Engineering Mechanics » ; Schaum - Metric edition, 1980
- J.L Fanchon "Guide de Mécanique" ; Nathan technique, 2008
- S. Pommier "Mécanique Générale" ; Dunod, 2010

Prerequisites

BSC 2nd degree level in mathematics:
vector calculation
integral and derivative calculus
Differential equation solving

Learning outcomes

Learning outcomes	N	A	M	E	O
• To position and parametrize rigid bodies	·	·	✓	·	·
To modelize mechanical actions					
• To find the motion equations	·	·	✓	·	·
To calculate unknown forces					
• To calculate provided and dissipated energies	·	✓	·	·	·

Manager : Jérémie RUPIL

Grammar and professional English 1

Hours

Lect	Tut	PW	Proj	WP	Asst
	40				

Evaluation

2 evaluations :

- *CC*
- *DS*

Grammar, Toeic and professional English 2

Hours

Lect	Tut	PW	Proj	WP	Asst
	39	2			

Evaluation

3 evaluations :

- *CC*
- *Tutorat*
- *Toeic*

Heat Convection

Hours

Lect	Tut	PW	Proj	WP	Asst
15	21.5	20			30

Evaluation

3 evaluations :

- *DS1*
- *TP*
- *DS2*

Outline

1. General Introduction, 2. Balance equations, 3. Laminar Boundary Layer Convection, 4. Internal Laminar Convection, 5. Natural Laminar Convection, 6. Turbulent boundary layer

Goals

The aim of this course is to provide a thorough understanding of the convective heat transfer phenomena. The analytical approach for solving systems of coupled differential equations and the use of correlations useful in engineering applications is discussed. Several practical examples illustrate the course.

Bibliography

- J. PADET; « Principes des transferts convectifs » ; Polytechnica, 1997
- S. KAKAC & Y. YENER; « Convective Heat Transfer » ; CRC Press, 1995, 2nd Edition
- P.H. OOSTHUISEN & D. NAYLOR; « Introduction to Convective Heat Transfer Analysis » ; WCB/McGraw-Hill, 1997

Prerequisites

Maths for Engineers, Fluid Mechanics, Thermodynamics.

Learning outcomes

Learning outcomes	N	A	M	E	O
• Mastering the fundamentals of convective heat transfer in laminar and turbulent flows	·	·	✓	·	·
• Using of correlations for thermal systems disign	·	·	✓	·	·
• Disigning the thermal equipments without phase change	·	✓	·	·	·

Manager : Ahmed GUELED

Heat Exchanger

Hours

Lect	Tut	PW	Proj	WP	Asst
12.5	10.5		1.5		12

Evaluation

One evaluation : *CR*

Outline

1. Description
   2. Convection and conduction
   3. Theory of the elementary heat exchanger
   4. Non uniformity of the heat tranfer coeficient
   5. Design of a cross flow heat exchanger
   6. Methodology (Heat balance, Exchange Surface, Performance)
   7. Efficiency of a Heat Exchanger
   8. NUT Metghod
   9. Durting and corrosion
   10. Plate heat exchanger
   11. Steam generator
   12. Drying
   13. Operation of a Steam generator
   14. Condenser
   15. Vaccum curves network
   16. Remooving of non-condensable gases
   17. Gas remooving in the condenser
   18. Cleaning

Goals

This course aims at giving to the future engineers the design methodology regarding heat exchangers both one and tw-phase flow. It aims alos at making them able to solve main prolems met by industry in this field.

Bibliography

- W.H. Mc Adams ; « Transmission de la chaleur » ; Dunod Paris, 1961
- F. Kneith ; « Transmission de la chaleur et thermodynamique » ; Masson Paris, 1967
- J.F. Sacadura ; « Initiation aux transferts thermiques » ; Lavoisier Paris, 1993
- J.P. Gupta ; « Fundamentals of Heat Exchanger and Pressure Vessel Technology » ; Hemisphere, 1986
- C. Marvillet, R. Vidil ; « Heat Transfer in Condensation and Evaporation : Application to Industrial and Environmental Processes » ; Proceeding of the Eurotherm Seminar n62, 17-18 nov. 1998, Grenoble, France
- L.S. Tong; « Boiling Heat Transfer and Two Phases Flows » ; John Wiley, New York, 1965
- Kutateladze, Borishanskii ; « A Concise Encyclopedia of Heat Transfer » ; Pergamon Press, 1966
- D. Chisholm ; « Developments in Heat Exchanger Technology » ; Applied Science Publishers LTD, 1980

Prerequisites

- Mathématics
  - Heat Conduction
  - Heat Convection

Learning outcomes

Learning outcomes	N	A	M	E	O
• Knowing the different kinds of heat exchangers	·	·	✓	·	·
• Designing an one phase or a two-phase heat exchanger	·	✓	·	·	·
• Choosing a device and applying supplier data	·	✓	·	·	·

Manager : Jérôme BELLETTRE

Heat Transfer in Processes

Hours

Lect	Tut	PW	Proj	WP	Asst
20	1.5	16			

Evaluation

2 evaluations :

- *CR1*
- *CR 2*

Bibliography

Mise en forme des polymères (4Éd.) Approche thermomécanique de la plasturgie, J.-F. Agassant, P.Avenas, J.-P.Sergent, B.Vergnes, M.Vincent, Lavoisier, ISBN-13 : 978-2743015497

V.Sobotka, D.Delaunay, R.Legoff, A.Agazzi, ?Optimisation thermique des outillages d'injection thermoplastique?, Techniques de l'ingénieur, AM3687, 26 pages, juin 2018

Heat Transfers in Polymer Composite Materials: Forming Processes, ISTE Ltd.(nov. 2015), ISBN-13: 978-1848217614.

Learning outcomes

Learning outcomes	N	A	M	E	O
• Analyze thermal phenomena in forming processes	·	✓	·	·	·
• Know how to justify the simplifying assumptions to analyze heat transfer in processes	·	·	✓	·	·

Manager : Vincent SOBOTKA

History of organizations and Accounting business game

Hours

Lect	Tut	PW	Proj	WP	Asst
9	10.5	12			5

Evaluation

One evaluation : *Soutenance + CC*

Learning outcomes

Learning outcomes	N	A	M	E	O
• TPN-1	✓	·	·	·	·
• TPN-2	·	✓	·	·	·
• TPN-3	✓	·	·	·	·
• TPN-4	·	✓	·	·	·

Manager : Chrystèle GONCALVES

Industrial Project

Hours

Lect	Tut	PW	Proj	WP	Asst
			130		75

Evaluation

One evaluation : *Rapport+SO*

Outline

Example of project subjects :

- Numerical model regarding a thermodynamic water heater
- Study of supplying a fuel cell with syngas from biomass
- Design of heat controler for electronic devices
- Battery cooling design
- Comparison between two kind of solar air conditioning systems
- Coupling a heat pump and solar panels
- Modeling of self-heating tools for composite materials
- Temperature control of fuel cell for a Shell-Eco Marathon car

Goals

This work is an integrated project performed by two students. The work focuses on a comprehensive problem given by one of our industrial partners. The students have to elaborate a real solution. Their are coached both by academic teachers and industrial partners.

Bibliography

Spécifique à chaque projet

Prerequisites

All the courses given during the first two years

Learning outcomes

Learning outcomes	N	A	M	E	O
• Answering to a techniqual problem expressed by an industrial partner	·	✓	·	·	·
• Working in a team	·	✓	·	·	·
• Presenting main results both orally and in a report	·	✓	·	·	·

Manager : Vincent SOBOTKA

Industrial simulation softwares

Hours

Lect	Tut	PW	Proj	WP	Asst
	21				

Evaluation

One evaluation : *CR*

Presentation

In the « Codes Métiers » module, students are teached how to perform numerical simulations with Finite Volumes (ANSYS FLUENT) and Finite Elements (Comsol Multiphysics). Several simulation cases are implemented, 2-dimensional then in 3-dimensional. Different simulation methods of the same case are performed and compared. The knowledge of those industrial tools and the ability to evaluate the reliability of their results are progressively mastered through the training sessions.

Outline

1) Initiaition to the use of the softwares Fluent and Comsol Multiphysics.

2) Build the simulation cases of different physical situations that highlight the essential possibilities of both simulation codes.

3) Analysis of results, discussion about the physical and numerical models

Goals

In the « Codes Métiers » module, students are teached how to perform numerical simulations with Finite Volumes (ANSYS FLUENT) and Finite Elements (Comsol Multiphysics). The aim is to develop a critical analysis of the simulation results. Several simulation methods of the same case are performed and compared. Simulation tutorials are carried out in 2D and 3D. The knowledge of those industrial tools and the ability to evaluate the reliability of their results is the core of the added value brought by a junior engineer.

Prerequisites

Course of Linear and Differential Systems (TE4). Course of Approximation Methods, finite differences, finite elements (TE4). General knowledge in heat transfers, fluid mechanics, continuum mechanics.

Learning outcomes

Learning outcomes	N	A	M	E	O
• Set up a Finite Volume calculation with the software FLUENT©	·	·	✓	·	·
• Set up a Finite Elements calculation with the software COMSOL Multiphysics 4.3©	·	·	✓	·	·
• Analyse numerical results and their reliability	·	·	✓	·	·

Manager : Dominique TARLET

Intercultural explorations

Hours

Lect	Tut	PW	Proj	WP	Asst
	18				

Evaluation

One evaluation : *CC*

Internship 3rd year

Hours

Lect	Tut	PW	Proj	WP	Asst
				8	

Evaluation

One evaluation : *Conv/grille*

Learning outcomes

Learning outcomes	N	A	M	E	O
• l	·	✓	·	·	·
• l	·	✓	·	·	·
• l	·	✓	·	·	·
• l	·	✓	·	·	·

Manager : Jérémie RUPIL

Internship 4th year

Hours

Lect	Tut	PW	Proj	WP	Asst
				13	

Evaluation

One evaluation : *Doc (Conv/grille/RA)*

Learning outcomes

Learning outcomes	N	A	M	E	O
• l	·	·	·	✓	·
• l	·	·	✓	·	·
• l	·	·	✓	·	·
• l	·	·	✓	·	·

Manager : Vincent SOBOTKA

Introduction to material science

Hours

Lect	Tut	PW	Proj	WP	Asst
7.5	7.5	12			24

Evaluation

3 evaluations :

- *DS*
- *CR TP+SO*
- *CC*

Outline

1. Introduction
   2. Chemical bounds and properties
   3. Crystallography : from chemical bound to solid
   4. Thermodynamics basics : phase diagrams
   5. Microstructures and properties
   6. Forming and assembling processes : influence on properties
   7. In use materials degradation

Goals

To get basic knowledge of materials science in order to be able to understand materials related issues encoutered in industry, espacially in heat exchange, cooling and energy industries.

Bibliography

Phase diagrams for binary alloys, Hiroaki Okamoto, ASM international; Des Matériaux, Jean-Paul Baïlon, Jean-Marie Dorlot, Presses Internationales Polytechnique; Phase transformations in metals and alloys, David A. Porter, Kenneth E. Easterling, Mohamed Y. Sherif, CRC Press Taylor & Francis Group; Physical Foundations of Materials Science, G. Gottstein, Springer;Introduction to Materials Science for Engineers, James F. Shackelford, Prentice Hall

Prerequisites

Thermodynamics and basis of chemistry

Learning outcomes

Learning outcomes	N	A	M	E	O
• To know how to read a phase diagram	·	✓	·	·	·
• To know the different corrosion mechnisms and to know how to avoid those	✓	·	·	·	·
• To know the links between chemical bounds, microstructures and materials properties	✓	·	·	·	·
• To know how to read CCT and TTT diagrams	·	✓	·	·	·
• To know the main forming and joining processes and their influence on materials properties	✓	·	·	·	·
• To know the main properties of structural materials, to know what they describe, how to measure them and how they can be modified	✓	·	·	·	·

Manager : Laurent COUTURIER

Inverse Problems

Hours

Lect	Tut	PW	Proj	WP	Asst
9		6	8		8

Evaluation

One evaluation : *Projet*

Outline

- Description of inverse problems with repect to direct problems
  - Formulation of cost functionsthat quantify errors
  - Formulation of optimization problems
  - Solution de optimisation problems (zero-order and gradient-type methods)
  - Gauss-Newton algorithm and related algorithms
  - Sensitivity to errors
  - Regularisation of Tikhonov, and methods of Levenberg-Marquardt
  - Project in the field of steady diffusion where the goal is to retrieve an unknown space dependent flux on a boundary

Goals

This course deals with the formulation and the description of resolution techniques in the field of inverse heat transfer problems which are mainly different from direct problems in the sense that their formulation consists in estimating the cause from the observation of the effect.

Bibliography

- K. A. Woodbury ; « Inverse Engineering Handbook » ; CRC Press, 2002

Learning outcomes

Learning outcomes	N	A	M	E	O
• Be able to « formulate » an inverse problem and distinguish them from the direct problems	·	·	✓	·	·
• Solve the associated optimization problem through basic iterative methods (Gauss-Newton for instance), and free-gradient zero-order algorithms	·	✓	·	·	·
• Know the basic notions of stability and necessary regularization. Be able to learn further in order to solve industrial inverse problems with high number of degrees of freedom	✓	·	·	·	·

Manager : Yann FAVENNEC

Linear and differential systems

Hours

Lect	Tut	PW	Proj	WP	Asst
10	22.5		6		

Evaluation

2 evaluations :

- *DS*
- *CC*

Outline

1. Linear systems: General introduction on scientific computing, Direct methods: Cramer, Gauss-pivot, LU and Cholesky decompositions, Error estimation for perturbed systems, matrix norms and condition numbers, Iterative methods : Jacobi, Gauss-Seidel and SOR methods, convergence, Gradient-type methods : Steepest, conjugate gradients, Applications on non-linear systems and on fitting

2. Differential systems: Cauchy problems, Order reduction, matrix exponentials, Euler methods, algorithmic, 4th order Runge-Kutta, Notions of consistance and stability. Applications on explicit and implicit schemes on parabolic-type problems

Goals

This course which is in the field of scientific computation gives basic numerical methods and tools for solving continuous physical problems. Two main notions are developped : solution of linear systems, then numerical solution of differential systems. We point out the necessary compromise between CPU time, accuracy and stability.

Bibliography

- P. Lascaux, R. Théodor ; « Analyse numérique matricielle appliquée à l'art de l'ingénieur, tome 1 et 2 » ; Dunod, 2000
- J. P. Grivet ; « Méthodes numériques appliquées pour le scientifique et l'ingénieur » ; EDP Sciences, 2009
- L. Amodei et J.P. Dedieu ; « Analyse numérique matricielle » ; Dunod, 2008
- A. Quateroni, R. Sacco, F. Saleri ; « Méthodes numériques pour le calcul scientifique » ; Springer, 2000
- J. P. Demailly ; « Analyse numérique et équations différentielles » ; EDP Sciences, 2006
- E. Belorizky ; « Outils mathématiques à l'usage des scientifiques et ingénieurs » ; EDP

Learning outcomes

Learning outcomes	N	A	M	E	O
• Know and understand basic different methods for the solution of linear systems and differential systems	·	·	✓	·	·
• Choose pertinently among the methods the ones adapted to the particular problem of concern. Quantify computation time and accuracy	·	✓	·	·	·
• Be able to write down simple algorithms	·	✓	·	·	·
• Be able to extrapolate its own knowledge for more complex or bigger systems	✓	·	·	·	·

Manager : Yann FAVENNEC

Mechanical Vibrations

Hours

Lect	Tut	PW	Proj	WP	Asst
10.5	12.5	9.5			10

Evaluation

2 evaluations :

- *CR TP*
- *DS*

Outline

Content of lectures:

-Main points: Application domain, Problem statement, theory of linear vibration, Théorie linéaire des vibrations.

-One DOF systems: Free oscillation of non-damped systems, Free oscillation of damped systems, Steady state vibration.

-Multi DOF systems: Momentum equations, free oscillation of non-damped systems, Free oscillation of damped systems, Steady state vibration, spectral analysis, modal analysis.

Content of tutorials

Momentum equation, Lagrange equations, Determination of free and forced oscillations, modal analysis, spectral analysis.

Content of practicals:Free and forced linear oscillations, damped and non-damped system. Balancing bench: spectral analysis (FFT) modes, vibrating table: dynamic damping (FFT).

Goals

This course is dedicated to the modelling and the solving of vibrations phenomena in solids. One- and multi-degree-of-freedom systems are considered. Natural frequencies and modes of vibrations, resonance, beat phenomenon, effect of damping and methods to avoid excessive vibrations are detailed.

Bibliography

- M. Del Pedro ; « Mécanique vibratoire » ; Presses polytechniques romandes, 1992
- M. Lalanne ; « Mécanique des vibrations linéaires » ; Masson, 1992
- A. Lecerf ; « Physique des ondes et des vibrations » ; Lavoisier, 1993

Prerequisites

- General Mechanics
- Strength of Materials

Learning outcomes

Learning outcomes	N	A	M	E	O
• Become proficient in the modeling and analysis of one-dof-systems - free vibrations, transient and steady-state forced vibrations, viscous damping.	·	·	✓	·	·
• Become proficient in the modeling and analysis of multi-dof systems - Lagrange's equations, modal analysis	·	·	✓	·	·

Manager : Vincent SOBOTKA

Modeling and Optimisation of Energy Systems

Hours

Lect	Tut	PW	Proj	WP	Asst
9	12				10

Evaluation

One evaluation : *Rapport*

Outline

1. Exergy analysis of thermodynamic cycles 2. Combined gas-vapor cycle 3. Exergy analysis of refrigeration systems 4. Combined Heat and Power Systems

Goals

This course is successive to the course "Energy systems" given in the semester 7. In the course "Energy Systems", exergy analysis has been introduced. In this course, exergy analysis is extensively used so that the students become experts in its using. Advanced energy cycles are studied: combined gas-vapor cycle and multi level temperature refrigeration system. Finally Combined Heat and Power systems are studied for which a set of pertinent energy efficiecny criteria is exposed.

Bibliography

- D.E. Winterbone ; « Advanced Thermodynamics for Engineers » ; Arnold, 1997
- Adrian Bejan ; « Entropy Generation Minimization » ; CRC Press, 1996
- Pierre Le Goff ; « Energétique industrielle » ; Technique et Documentation, 1979, Tome

Prerequisites

Fluid mechanics, energy systems, applied thermodynamics, thermodynamics, turbomachinery.

Learning outcomes

Learning outcomes	N	A	M	E	O
• To be able to calculate the energy degradation during real elementary processes (compression/expansion, heat transfer, chemical reaction,...)	·	·	·	✓	·
• To be able to set an energy and exergy flow diagram for an industrial systems	·	·	·	✓	·
• To be able to define a proper energy efficiency criterion to an energy conversion or transfer process	·	·	·	✓	·

Manager : Bruno AUVITY

Multi-species two phase convection

Hours

Lect	Tut	PW	Proj	WP	Asst
13.75	12.5		6		15

Evaluation

3 evaluations :

- *CRSO*
- *1 DS*
- *CC*

Outline

1. Introduction to Phase Change phenomena, 2. Condensation, 3. Boiling, - Pool Boiling, - Forced Convection Boiling, 4, Heat Pipes

Goals

This course deals with two-phase flow and liquid-vapor phase changes that are involved in many natural phenomena and industrial applications. This course will enable students to acquire the basic physical concepts for liquid / vapor phase changes and relationships governing the heat transfer in these conditions which are often empirical.

Bibliography

- Karl Stephan ; « Heat Transfer in Condensation and Boiling » ; Spring-Verlag, 1992
- Van P. Carey ; « Liquid-Vapor Phase-Change Phenomena - An introduction to the thermophysics of vaporization and condensation process in heat transfer equipment » ; Taylor & Francis, 1992
- J.G. Collier & J.R. Thome; « Convective Boiling and Condensation » ; Oxford University Press, 1994
- E. Hahne & U Grigull ; « Heat Transfer in Boiling » ; Academic Press - Hemisphere Publishing corporation, 1977
- D. Butterworth & G.F. Hewitt ; « Two-Phase Flow and Heat Transfer » ; Oxford University Press, 1977

Prerequisites

Maths for Engineers, Fluid Mechanics, Thermodynamics, Convective Heat Transfer without phase change.

Learning outcomes

Learning outcomes	N	A	M	E	O
• Mastering the fundamentals of convective heat transfer with change of phase	·	·	✓	·	·
• Using of correlations for thermal systems disign	·	·	✓	·	·
• Disigning the thermal equipments with phase change	·	✓	·	·	·

Manager : Ahmed GUELED

Negotiations

Hours

Lect	Tut	PW	Proj	WP	Asst
3	7.5				2

Evaluation

One evaluation : *Vidéo*

Bibliography

Stimec A. ; « La négociation » ; Dunod
Fisher, Ury ; « Comment réussir une négociation » ; Seuil

Learning outcomes

Learning outcomes	N	A	M	E	O
• TPN-1	·	✓	·	·	·
• TPN-2	·	✓	·	·	·
• TPN-4	✓	·	·	·	·

Manager : John KINGSTON

People and team management

Hours

Lect	Tut	PW	Proj	WP	Asst
	10.5				6

Evaluation

One evaluation : *DS*

Bibliography

- Le chaos Management / Tom Peters / Intereditions
- Manager dans la complexité / Dominique Genelot / Insep Editions
- Les responsables porteurs de sens / Vincent Lenhardt / Insep Editions
- De la performance à l'excellence / Jim Collins / Village Mondial
- Comment leur dire / Gérard Collignon / Intereditions
- Communiquer, motiver, manager en personne/ Taibi Kahler / Intereditions
- Vidéos d'Edgar Morin sur la complexité / Youtube
- Management et communication : 100 exercices / Denis Cristol / ESF editeur

Learning outcomes

Learning outcomes	N	A	M	E	O
• TPN-1	✓	·	·	·	·
• TPN-2	✓	·	·	·	·
• TPN4	✓	·	·	·	·
• TPN-6	✓	·	·	·	·

Manager : Anouk GREVIN

Physical education and sport 1

Hours

Lect	Tut	PW	Proj	WP	Asst
	21				2

Evaluation

One evaluation : *Contrôle continu*

Learning outcomes

Learning outcomes	N	A	M	E	O
• TPN-1	·	✓	·	·	·
• TPN-2	·	✓	·	·	·
• TPN-3	✓	·	·	·	·
• TPN-4	✓	·	·	·	·
• TPN-5	·	✓	·	·	·
• TPN-3	✓	·	·	·	·
• TPN-7	✓	·	·	·	·
• TPN-12	✓	·	·	·	·
• TPN-19	✓	·	·	·	·

Manager : Jérôme BEZIER

Physical education and sport 2

Hours

Lect	Tut	PW	Proj	WP	Asst
	21				2

Evaluation

One evaluation : *Contrôle continu*

Learning outcomes

Learning outcomes	N	A	M	E	O
• TPN-1	·	✓	·	·	·
• TPN-2	·	✓	·	·	·
• TPN-3	✓	·	·	·	·
• TPN-4	✓	·	·	·	·
• TPN-5	·	✓	·	·	·
• TPN-3	✓	·	·	·	·
• TPN-7	✓	·	·	·	·
• TPN-12	✓	·	·	·	·
• TPN-19	✓	·	·	·	·

Manager : Jérôme BEZIER

Physical education and sport 3

Hours

Lect	Tut	PW	Proj	WP	Asst
	21				2

Evaluation

One evaluation : *Contrôle continu*

Learning outcomes

Learning outcomes	N	A	M	E	O
• TPN-1	·	✓	·	·	·
• TPN-2	·	✓	·	·	·
• TPN-3	✓	·	·	·	·
• TPN-4	✓	·	·	·	·
• TPN-5	·	✓	·	·	·

Manager : Jérôme BEZIER

Physical education and sport 4

Hours

Lect	Tut	PW	Proj	WP	Asst
	19.5				2

Evaluation

One evaluation : *Contrôle continu*

Learning outcomes

Learning outcomes	N	A	M	E	O
• TPN-1	·	✓	·	·	·
• TPN-2	·	✓	·	·	·
• TPN-3	✓	·	·	·	·
• TPN-4	✓	·	·	·	·
• TPN-5	·	✓	·	·	·

Manager : Jérôme BEZIER

Professional English 3

Hours

Lect	Tut	PW	Proj	WP	Asst
	19	2			

Evaluation

3 evaluations :

- *CC*
- *Tutorat*
- *DS*

Professional Project 2

Hours

Lect	Tut	PW	Proj	WP	Asst
	4.5				

Evaluation

One evaluation : *CV rendu*

Manager : Sylvaine GAUTIER

Professional Project 4

Hours

Lect	Tut	PW	Proj	WP	Asst
	12				5

Evaluation

One evaluation : *Oral*

Outline

Path : 4 sessions of 3h TD

1 / Portfolio "Exploration Project Professional" : my "professionnel journey" those last years - changes - choices - motivations...

2 / My professionnal project : what I intended, the way to go, anticipate steps (especially the choice of option at the end of the fourth year)

3 and 4 / I introduce myself, my skills, my project : simulations and role plays

Goals

Clarify the professional project and be able to present it orally in different circumstances (professional network meetings, hiring individual or collective interview , student lounge, video resume, ..)

Bibliography

"Le Carnet de Route universitaire et professionnel" - SUIO de l'Université de Nantes - 2008

Prerequisites

Professionnal project 1 (S5)

Discovery of firms and professions (S6)

Learning outcomes

Learning outcomes	N	A	M	E	O
• TPN-1	✓	·	·	·	·
• TPN-2	✓	·	·	·	·
• TPN-3	✓	·	·	·	·
• TPN-5	✓	·	·	·	·
• TPN-6	✓	·	·	·	·
• TPN-7	✓	·	·	·	·

Manager : Sylvaine GAUTIER

Professional project 3

Hours

Lect	Tut	PW	Proj	WP	Asst
	6				6

Evaluation

One evaluation : *Profil linkedin+rdv*

Bibliography

Grant : Givers & Takers TED

Learning outcomes

Learning outcomes	N	A	M	E	O
• TPN-2	·	·	✓	·	·
• TPN-6	·	✓	·	·	·
• TPN-7	·	✓	·	·	·

Manager : John KINGSTON

Professional project 5

Hours

Lect	Tut	PW	Proj	WP	Asst
	12				2

Evaluation

One evaluation : *Présence*

Bibliography

Ressources : Évolueront selon les thématiques choisies par les intervenants - en lien avec les TPN et les objectifs de ce module.

Learning outcomes

Learning outcomes	N	A	M	E	O
• TPN-1	✓	·	·	·	·
• TPN-2	✓	·	·	·	·
• TPN-3	✓	·	·	·	·
• TPN-5	✓	·	·	·	·
• TPN-6	✓	·	·	·	·
• TPN-7	✓	·	·	·	·

Manager : Sylvaine GAUTIER

Professionnal project 1

Hours

Lect	Tut	PW	Proj	WP	Asst
1.5	12				4.5

Evaluation

One evaluation : *Contrôle continu*

Bibliography

- DE LASSUS René, L'analyse transactionnelle : une méthode révolutionnaire pour bien se connaître et mieux communiquer, Marabout (Savoir pratique n3516), 2013, 288 p., ISBN 2501085493

- DE LASSUS René, La communication efficace par la PNL, Marabout (Bien-être - Psy), 2019, 288 p., ISBN 2501089499

- DE LASSUS René, L'ennéagramme : les 9 types de personnalités, Marabout (Poche Psy n3568), 2019, 288 p., ISBN 2501084950

- DE MONICAULT Frédéric / RAVARD Olivier, 100 questions posées à l'entretien d'embauche, Jeunes Editions (Guides J), 2004 (3e édition), 182 p., ISBN-10 : 2844724221 / ISBN-13 : 978-2844724229

- LEONARD Thomas J., The portable coach, Simon & SCHUSTER, 1999, 336 p., ISBN-10 : 0684850419 / ISBN-13 : 9780684850412

- ROSENBERG Marshall B., Les mots sont des fenêtres (ou bien ce sont des murs) : initiation à la communication non-violente, La Découverte, 2016, 320 p., ISBN 2707188794

- www.16personalities.com

- www.acnv.com

Learning outcomes

Learning outcomes	N	A	M	E	O
• TPN-2	·	✓	·	·	·
• TPN-6	·	✓	·	·	·

Manager : Sylvaine GAUTIER

Project

Hours

Lect	Tut	PW	Proj	WP	Asst
			40		

Evaluation

3 evaluations :

- *Rapport*
- *SO*
- *CC*

Presentation

This teaching consists in the realization of a concrete transversal project in connection with the Thermal Energy Department. Students in groups of 5 to 7 will have to organize themselves to meet the specifications given at the start of the year.

Goals

Confronting a "professional" type project exercise.
Work as a team, get organized.
Deepen your knowledge in the theoretical and numerical fields.

Prerequisites

General mechanics
Strength of materials
Fluid mechanics
Thermal conduction
Thermal convection
Applied thermodynamics
General thermodynamics
Energy systems

Manager : Jérémie RUPIL

Project II

Hours

Lect	Tut	PW	Proj	WP	Asst
			55		

Evaluation

4 evaluations :

- *SO1*
- *Rapport*
- *SO2*
- *CC*

Presentation

This teaching consists in the realization of a concrete transversal project in connection with the Thermal Energy Department. Students in groups of 5 to 7 will have to organize themselves to meet the specications given at the start of the year.

Goals

Confronting a "professional" type project exercise.
Work as a team, get organized.
Deepen your knowledge in the theoretical and numerical elds.

Prerequisites

General mechanics
Strength of materials
Fluid mechanics
Thermal conduction
Thermal convection
Applied thermodynamics
General thermodynamics
Energy systems

Manager : Jérémie RUPIL

Project management 1

Hours

Lect	Tut	PW	Proj	WP	Asst
4.5		3			2

Evaluation

One evaluation : *DS*

Project management 2

Hours

Lect	Tut	PW	Proj	WP	Asst
	15				3

Evaluation

One evaluation : *Contrôle continu*

Bibliography

Partie analyse du travail : PIERRE VERMERSCH, 1994 « L'entretien d'explicitation », ESF éditeur

Learning outcomes

Learning outcomes	N	A	M	E	O
• TPN-1	✓	·	·	·	·
• TPN-2	·	✓	·	·	·
• TPN-3	·	✓	·	·	·
• TPN-4	✓	·	·	·	·
• TPN-5	·	✓	·	·	·

Manager : John KINGSTON

Quality, security and environmental approaches (QSE1)

Hours

Lect	Tut	PW	Proj	WP	Asst
	3	3			

Evaluation

One evaluation : *QCM+exercices*

Bibliography

Ressources documentaires disponibles sur madoc :

o Le Code du travail numérique

o Code de l'environnement LEGIFRANCE

o Les aventures de Napo vidéos d'animation INRS pour sensibilisation à la sécurité au travail

o Publications et outils de l'INRS Institut national de recherche et de sécurité

o AIDA : Site web des textes réglementaires du Ministère en charge de l'environnement

o Les fiches sur le fonctionnement des principales institutions de la République, l'organisation de l'Union européenne et les relations internationales

Learning outcomes

Learning outcomes	N	A	M	E	O
• TPN-1	✓	·	·	·	·
• TPN-3	·	✓	·	·	·
• TPN-4	✓	·	·	·	·
• TPN-5	✓	·	·	·	·

Manager : John KINGSTON

Quality, security ant environmental approaches (QSE2)

Hours

Lect	Tut	PW	Proj	WP	Asst
	6				

Evaluation

One evaluation : *QCM+exercices*

Bibliography

Références ou ressources documentaires disponibles sur madoc :

- Les fiches sur le fonctionnement des principales institutions de la République, l'organisation de l'Union européenne et les relations internationales
- Publications et outils de l'INRS Institut national de recherche et de sécurité
- Rapports détaillés des accidents industriels sur la base de donnée ARIA
- Outils MARP de Techniques de l'Ingénieur.

Learning outcomes

Learning outcomes	N	A	M	E	O
• TPN-1	✓	·	·	·	·
• TPN-3	·	✓	·	·	·
• TPN-4	✓	·	·	·	·
• TPN-5	✓	·	·	·	·

Manager : John KINGSTON

Real and vectorial Analysis

Hours

Lect	Tut	PW	Proj	WP	Asst
	21				10

Evaluation

One evaluation : *1 DS*

Manager : Yann FAVENNEC

Renewable energy

Hours

Lect	Tut	PW	Proj	WP	Asst
20.5					

Evaluation

One evaluation : *CC*

Outline

1. Introcduction conference
   2. Renewable energies :
   - Solar (PV and Thermal)
   - Hydrogène and Fuel cells
   - Wind
   - Biomass
   - Marine energies
   3. Case study

Goals

These conferences are given by researchers, industrials and members of institutions such as ADEME. They give to the students a global view regarding renewable energies. General conference explains firstly the Sustainable development context. Specific conference give secondly detailed information nregarding technology, economics and enviromnetal aspect for each kind of renewable energy. At the end, a individual case study is performed by the students,

Prerequisites

- Heat conduction
  - Heat convection
  - Fluid mechanics
  - Thermodynamics
  - Sustainable development

Learning outcomes

Learning outcomes	N	A	M	E	O
• Choosing a kind of renewable energy taking into account technical, economical, social and environmental aspects	·	✓	·	·	·
• Performing a relevance study for a given need of energy	·	✓	·	·	·

Manager : Jérémie RUPIL

Research S7

Hours

Lect	Tut	PW	Proj	WP	Asst
			32		

Evaluation

One evaluation : *Evaluation*

Manager : Antoine GOULLET

Research S8

Hours

Lect	Tut	PW	Proj	WP	Asst
			32		

Evaluation

One evaluation : *Evaluation*

Manager : Antoine GOULLET

Second foreign language - Japanese

Hours

Lect	Tut	PW	Proj	WP	Asst
	18				

Evaluation

One evaluation : *CC*

Second foreign language - Japanese

Hours

Lect	Tut	PW	Proj	WP	Asst
	18				

Evaluation

One evaluation : *CC*

Second foreign language - Sign language

Hours

Lect	Tut	PW	Proj	WP	Asst
	18				

Evaluation

One evaluation : *CC*

Second foreign language - Sign language

Hours

Lect	Tut	PW	Proj	WP	Asst
	18				

Evaluation

One evaluation : *CC*

Second foreign language - Spanish

Hours

Lect	Tut	PW	Proj	WP	Asst
	18				

Evaluation

One evaluation : *CC*

Second foreign language - Spanish

Hours

Lect	Tut	PW	Proj	WP	Asst
	18				

Evaluation

One evaluation : *CC*

Socio-economic debates and Tools for shifting

Hours

Lect	Tut	PW	Proj	WP	Asst
	21				10

Evaluation

One evaluation : *Exposé débat*

Bibliography

De nombreuses références seront proposées dans chacun des 6 thèmes (liens vidéos, articles et livres) ; quelques livres de base peuvent cependant servir à tous les thèmes :

- BRAQUET Laurent et MOUREY David, Comprendre les fondamentaux de l'économie, De Boeck, 2015, 475 p., ISBN 978-2-8041-9021-7
- BIASUTTI Jean-Pierre et BRAQUET Laurent, Les débats économiques d'aujourd'hui, Ellipses, 2019, 278p, ISBN 9782340-031210
- DESCAMPS Christian, L'analyse économique en questions, Vuibert, 2005, ISBN 2-71117-7413-9
- SINAÏ Agnès, Penser la décroissance, Sciences Po Les presses, 2018, 210 p, ISBN 9782724613001
- SINAÏ Agnès, Economie de l'après-croissance, Sciences Po Les presses, 2018, ISBN 9782724617559
- PIKETTY Thomas, Capital et idéologie, Seuil, 2019, ISBN 978-2-02-133804-1
- COHEN Daniel, Le monde est clos et le désir infini, Albin Michel, 2015, ISBN 978-2226240293

Learning outcomes

Learning outcomes	N	A	M	E	O
• TPN-3	✓	·	·	·	·
• TPN-4	✓	·	·	·	·
• TPN-1	·	✓	·	·	·
• TPN-2	·	✓	·	·	·
• TPN-3	·	✓	·	·	·
• TPN-8	✓	·	·	·	·
• TPN-9	✓	·	·	·	·
• TPN-10	·	✓	·	·	·
• TPN-11	✓	·	·	·	·

Manager : Chrystèle GONCALVES

Soft skills

Hours

Lect	Tut	PW	Proj	WP	Asst
	7.5				

Evaluation

One evaluation : *Examen:cas pratique*

Bibliography

- La confiance en gestion : un regard pluridisciplinaire (Boissieu & Oguchi, 2011)
- Trust Rules: How the World's Best Managers Create Great Places to Work (Lee, 2017)
- Give and Take: A Revolutionary Approach to Success (Grant, 2013)
- L'entreprise une affaire de don (Collectif, 2016)
- La théorie des jeux - Science étonnante
- Jeu sur l'évolution de la confiance
- The Office (NBC, 2005)
- Mad Men (HBO, 2007)

Learning outcomes

Learning outcomes	N	A	M	E	O
• TPN-1	✓	·	·	·	·
• TPN-2	✓	·	·	·	·
• TPN-4	✓	·	·	·	·
• TPN-6	✓	·	·	·	·
• TPN-5	✓	·	·	·	·
• TPN-6	✓	·	·	·	·
• TPN-7	✓	·	·	·	·
• TPN-12	✓	·	·	·	·
• TPN-13	✓	·	·	·	·
• TPN-20	✓	·	·	·	·
• TPN-21	✓	·	·	·	·

Manager : Roland BESSENAY

Solar thermal and geothermal energy

Hours

Lect	Tut	PW	Proj	WP	Asst
12	3	6	3		

Evaluation

One evaluation : *1 DS*

Presentation

The course "Thermal Solar Processes and near-surface geothermy" is composed of lectures and tutorials dedicated to the different unit operations and corresponding domestic or industrial applications. The principles and technologies of solar radiation capture, concentration and conversion are described as well as thermal storage and systems exploiting high temperature thermal production. The main industrial applications of the energetic transition are presented, in particular concentrated solar power plants, industrial heat production, seawater desalination,... These processes are compared to conventional processes, in particular according to the criteria of life cycle analysis, CAPEX or OPEX. Finally, the current research works are presented. The principles and thermal applications of near-surface geothermal energy are also covered. The technologies used are presented and compared, with tutorials providing an opportunity to identify limitations and consider potential improvements

Outline

(1) the solar resource
  (2) the principles of concentration
  (3) Concentration technologies
  (4) materials (absorbers, storage, heat transfer fluids)
  (5) industrial applications for the energy transition
  (6) environmental impacts, LCA
  (7) general description of near-surface geothermy
  (8) near-surface geothermy technologies
  (9) near-surface geothermy limitations and improvments

Goals

The different objectives of this course are : to know the various concentrated solar technologies and near-surface geothermy, their respective advantages and disadvantages, their differentiating criteria with respect to competing processes, to be able to choose which one would be the most relevant in a given context and finally to be able to envisage new applications.

Bibliography

La bibliographie est fournie pendant les enseignements, on pourra également se reporter aux documents mis à disposition de SolarPaces ou de l'IAE.

Prerequisites

L-level knowledge in thermic, energetic and fluid mechanics are required.

Learning outcomes

Learning outcomes	N	A	M	E	O
• knowledge of the various concentrating solar technologies	✓	·	·	·	·
• choice of the relevant concentrating solar tech	·	·	✓	·	·
• design of a concentrating solar device	·	✓	·	·	·
• knowledge of near surface geothermal technologies	✓	·	·	·	·
• identification of limiting effects in near-surface geothermy	·	·	✓	·	·
• design of near-surface geothermal system	·	✓	·	·	·

Manager : Xavier PY

Storage and decarbonization

Hours

Lect	Tut	PW	Proj	WP	Asst
7	2				

Evaluation

One evaluation : *1 DS*

Presentation

The different types of thermal storages (technologies, materials and systems, including their integration) are presented. Sensible, latent and thermo-chemical heat storage are discussed in comparative terms, with advantages/disadvantages illustrated by concrete examples from the energy transition. Finally, a special section is devoted to the decarbonization of industry and dedicated thermal storage (recovery/upgrading of industrial waste heat, etc.).

Outline

(1) various energy storage approaches
  (2) thermal energy storage
  (3) sensible heat based thermal storage
  (4) latent heat based thermal storage
  (5) thermochemical energy storage
  (6) thermal storage and decarbonation

Goals

By the end of the course, engineering students will master the general principles and technologies of different thermal storage systems. They will be able to choose the most suitable one for a given application, and will also be able to guide the choice of associated materials. A specific focus will be dedicated to the emerging case of industrial decarbonation.

Bibliography

Divers documents bibliographiques de référence (review) seront mis à disposition (sous forme de pdf téléchargeables) couvrant les domaines du stockage thermique et de la décarbonation. Au delà des publications académiques sur le sujet, des documents de référence sur les expertises (AIE, ADEME,...) et orientations (plan neutralité carbone, ...) seront également proposés.

Prerequisites

Basic knowledges on thermal science (thermodynamic, heat transfer) and fluid mechanics are needed

Learning outcomes

Learning outcomes	N	A	M	E	O
• knowledge of available thermal storage systems	✓	·	·	·	·
• choise of the relevant thermal energy storage	·	·	✓	·	·
• choice of relevant thermal energy storage materials	·	·	✓	·	·
• issues, challenges and strategy of decarbonation	✓	·	·	·	·

Manager : Xavier PY

Structural Mechanics

Hours

Lect	Tut	PW	Proj	WP	Asst
16.25	21.25	15			20

Evaluation

3 evaluations :

- *TP*
- *DS1*
- *DS2*

Outline

Internal forces - Diagrams
Resistance criterions - Security
Beam theory : Traction, Compression, Bending
Thenologic Shearing, Shearing in bended beams, Torsion
Combined sillicitations
Thin wall beams
Energetic methods
Subjects of practicals :
Mechanical characteristics measures
Isostatic and hyperstatic gantries
Shear in thin wall beams
Stress concentrations, Photoelasticity measures
Numerical simulation of a gantry problem

Goals

To determine internal forces in a deformable solid
To determine stresses and displacements in a structure
To size through the use of strength criterions
To characterize mechanical properties of a material
To optimize by choosing material and dimensions

Bibliography

Résistance des matériaux par Giet & Géminard - Editions Dunod
Résistance des matériaux par Kerguignas & Caignaert - Editions Dunod
Résistance des Matériaux par A. Bazergui - Editions Polytech. Montréal

Prerequisites

Statics of rigid bodies
Theory of elasticity

Learning outcomes

Learning outcomes	N	A	M	E	O
• To determine internal forces in a deformable solid	·	·	✓	·	·
• To Determine stresses and strains in a structure	·	·	✓	·	·
To size through the use of strength criterions					
• To characterize mechanical properties of a material	·	·	✓	·	·

Manager : Steven LE CORRE

Sustainable development and social responsability 1

Hours

Lect	Tut	PW	Proj	WP	Asst
1.5	13.5				

Evaluation

One evaluation : *Grille d'évaluation*

Bibliography

- Travaux du GIEC
- Global carbon project

Learning outcomes

Learning outcomes	N	A	M	E	O
• TPN-3	✓	·	·	·	·

Manager : Laurence CHARPENTIER

Sustainable development and social responsability 2

Hours

Lect	Tut	PW	Proj	WP	Asst
	9				10

Evaluation

One evaluation : *Soutenance + Rapport*

Bibliography

- Travaux du GIEC
- Global carbon project

Learning outcomes

Learning outcomes	N	A	M	E	O
• TPN-3	·	✓	·	·	·
• TPN-5	·	✓	·	·	·

Manager : Laurence CHARPENTIER

Technology in Refrigerating Plant

Hours

Lect	Tut	PW	Proj	WP	Asst
35		4			20

Evaluation

3 evaluations :

- *CR Proj*
- *TP2*
- *TP1*

Outline

1. technology
   - The refrigerant circuit of basis
   - Technology compressors (reciprocating, centrifugal ,screw, scroll...)
   - Lubrication and refrigeration oils
   - Refrigerants (context and usage constraints, legislation)
   - The expansion systems and supply evaporators
   - Technology evaporators and condensers
2. cold balance
3. Using enthalpy diagrams
   - Study of various refrigeration cycles (single and dual stage, full and partial injection)
   - Determination of compressors and heat exchangers
4. refrigerating plant tour

Goals

The aim of this technological course is to understand the energy issues and environmental constraints encountered during the design and the building of a refrigerating plant. After a presentation of the different elements of a refrigerating system, the dimensioning and choosing criteria of different cycles is presenting, in order to evaluate their energetic efficiency with respect to the specifications of the desired factory.

Bibliography

- W. Maake, H.J.Eckert et J.L.Cauchepin ; « le Pohlmann »
- PJ Rapin et P Jacquard ; « Installations Frigorifiques » ; PYC Editions
- HUGO NOACK et Rolf Seidel ; « Pratique des installations frigorifiques » ; PYC Editions
- « la Revue Générale du Froid » ; AFF
- « la Revue Pratique du Froid »

Prerequisites

-Thermodynamics systems
- Applied Thermodynamics
- General Thermodynamics
- Turbomachinery

Learning outcomes

Learning outcomes	N	A	M	E	O
• to choose and dimension heat exchangers and compressors of cooling plants	·	·	✓	·	·
• to know the different refrigeration cycles and to compare their performances	·	·	✓	·	·
• to know the current legislation	·	✓	·	·	·

Manager : Christophe JOSSET

Thermal Mechanics Dimensioning

Hours

Lect	Tut	PW	Proj	WP	Asst
9	19.5				15

Evaluation

2 evaluations :

- *1 DS*
- *CR*

Presentation

Through various practical cases (pressurized vessel, shrinking, expansion joints, ...) treated analytically or numerically, this course highlights the main principles of design in the case of thermomechanical loading in order to understand the origins and practical resolution methods.

Outline

Simple rheological models (1D).
Damage due to thermal shock (application: temperature resistance of an industrial ceramic).
1D thermomechanics (hyperstatic structure, RDM).
3D thermomechanics (pressure vessel, shrinking).
Thermomechanical buckling.

Goals

To understand the different physical phenomena of damage to a part or a structure subjected to thermomechanical loading: thermal shock, hyperstatic structure, differential expansion.

To be able to solve analytically a simple problem of thermomechanics (1D) using simple rheological models and the theory of the RDM.

Address the simple 3D analytical problems in thermomechanics (pressurized tank, hooping).

To be able to dimension a part or system subjected to thermomechanical loading using the COMSOL multiphysics software.

Bibliography

- J. Lemaître et J.L. Chaboche ; « Mécanique des matériaux solides » ; Dunod
- S. Timoshenko ; « Résistance des matériaux » ; Dunod, Tome 2
- M. Géradin et D. Rixen ; « Théorie des vibrations » ; Masson
- Y. Bamberger ; « Mécanique de l'ingénieur » ; Hermann, 4 tomes
- F. P. Incropera and D. P. Dewitt ; « Fundamentals of Heat and Mass Transfer » ; J. Wiley edition
- M. N. Ozisik ; « Heat Conduction » ; J. Wiley edition

Prerequisites

Strength of materials ;
Thermal conduction and convection

Learning outcomes

Learning outcomes	N	A	M	E	O
• To size a solid under thermal and mechanical load To operate the thick cylinder theory	·	·	✓	·	·
• To solve multiphysic problems by numerical simulation with COMSOL	·	·	✓	·	·

Manager : Jérémie RUPIL

Thermal Radiation

Hours

Lect	Tut	PW	Proj	WP	Asst
16.25	16.5	20			25

Evaluation

2 evaluations :

- *CR TP*
- *1 DS*

Outline

Chapter 1 Fundamentals of thermal radiation
-general considerations
-Solid angles, emissive power, radiative intensity, irradiation
-Basic laws of thermal radiation (Planck's law, Stefan Boltzman law, cosinus law)
Chapter 2 Radiative heat exchange between black surfaces
-View factors
-radiative heat flux
-energy balance on a surface with heat convection and conduction heat exchange
-Solution methods for heat exchange problems in enclosures consisting of black surfaces
Chapter3- Radiative heat exchange between non-black surfaces
-radiative properties of real surfaces (emissivity, absorptivity, reflectivity)
-Kirchoff laws
-Radiosity
-Radiative exchange between gray and diffuse surfaces
-Electrical network analogy
-Radiation shields
-Solution methods of combinated problems
Chapter 4- Basics of radiative transfer in participating media
-Radiative properties of semi-transparent media
-Radiative transport equation
-radiation exchange in inclosures with gray absorbing emitting media

Goals

This course provides a treatment of thermal radiation including the basic physics and their applications to thermal engineering issues. It gives models, methodologies and calculations for solving combined heat transfer problems for academic research and industry. Applications include different topics such as thermal engineering, solar energy, high temperature processes. The course is dealing with radiative properties of opaque surfaces, radiative exchange between opaque surfaces in an enclosure, the basics of radiative exchange in participating media.

Bibliography

- Frank P. Incropera, David P. deWitt ; « Fundamentals of Heat and Mass Transfer » ;
John Wiley & Sons, 1996
- Michael F.MODEST; « Radiative Heat Transfer » ; McGRAW-HILL International Editions,
1993

Learning outcomes

Learning outcomes	N	A	M	E	O
• Knowledge about emission and absorption properties of matter	·	·	✓	·	·
• Calculate view factors and solve radiative equations in enclosures	·	·	✓	·	·
• Establish energy balance equations with thermal radiation to solve combined heat transfer problems	·	·	✓	·	·

Manager : Yann FAVENNEC

Thermal and networks

Hours

Lect	Tut	PW	Proj	WP	Asst
9	2				

Evaluation

One evaluation : *1 CR*

Presentation

The "thermics and networks" course is designed to address the contribution of thermal science to the management/optimization of networks (electricity and thermal networks). Particular attention will be paid to the case of "Power-to-Heat" and associated thermal storage systems, and more generally to the contribution of thermal storage to the massive integration of variable renewable energies (VRE) into networks. Power-to-Heat will also be discussed in the light of the opportunities offered by SPOT-type electricity exchanges.

Outline

(1) issues of massive integration of VRE in networks
(2) energy storage inputs in massive VRE integration
(3) Power-to-Heat technologies
(4) Power-to-Heat with energy storage for SPOT type marckets

Goals

By the end of the course, engineering students will master the concepts and general principles of thermal engineering technologies that provide the networks with the various services expected as part of the transition. This is specifically the case for "power-to-heat", and the contribution of thermal storage to the massive integration of variable renewable energies into networks.

Bibliography

les éléments bibliographiques issus des expertises de l'AIE, ADEME et autres seront mis à disposition ainsi que des publications récentes sur le sujet.

Prerequisites

basic knowledge of thermal and fluid mechanics is required

Learning outcomes

Learning outcomes	N	A	M	E	O
• contribution of thermal systems to networks	✓	·	·	·	·
• emerging technologies of Power-to-heat	·	✓	·	·	·
• heat and coldeness networks	·	✓	·	·	·

Manager : Xavier PY

Thermal measurement

Hours

Lect	Tut	PW	Proj	WP	Asst
11.25	1.5				

Evaluation

One evaluation : *1 DS*

Outline

Chapter 1- Introduction

- Considerations for electrical detection and instruments (time response, bandwith, resolution, precision).
- Calculation and methodologies for error analysis

Chapter 2- Temperature measurement

- Thermocouples, resistance thermometry, semiconductor sensors
-Infra-red thermometry (radiometric equation, infrared detectors, methodologies for temperature detection)
- Errors analysis for contact and non-contact thermometry

Chapter 3- Thermal measurement

- Measurement of heat flux
-Calorimetry
-Measurement of thermal properties of solids, liquids, and gases (steady-state and dynamic techniques)
-applications

Goals

This course provides the basic physics, the principles and techniques of thermal measurement for controlling and designing thermal and energy systems and processes. The course includes the properties and use of temperature sensors and their calibration, electrical and infra-red radiation thermometry, measurement of thermal properties, calorimetry and measurement of heat flux

Bibliography

- John G. WEBSTER; « Measurement, Instrumentation and Sensors Handbook » ; CRC Press, 1999
- G.ASCH; « Les capteurs en instrumentation industrielle » ; Dunod, 1991
- F. DESVIGNES; « Rayonnements Optiques, Radiométrie, Photométrie » ; MASSON, 1996
- DP DEWITT-GENE D.NUTTER; « Theory and Practice of radiation thermometry » ; WILEY interscience publication, 1998
- « Techniques de l'Ingénieur » ; Nombreux articles du volume Mesures Physiques

Learning outcomes

Learning outcomes	N	A	M	E	O
• Knowledge for controlling thermal measurement systems and conducting tests	·	·	✓	·	·
• Ability for designing, implementing, and operating thermal measurement systems	·	·	✓	·	·
• Knowledge about techniques for measuring temperature, heat flux, and thermal properties of solids liquids and gases	·	·	✓	·	·

Thermodynamic Systems

Hours

Lect	Tut	PW	Proj	WP	Asst
7.5	12		9		

Evaluation

4 evaluations :

- *DS1*
- *CC*
- *DS2*
- *CR*

Presentation

This course is focused on energy systems in which energy under a given form (chemical energy, thermal energy, mechanical energy, electrical energy) is converted into another form of energy. Gas and vapor turbines are studied in their most common configurations for stationnary and transport applications. Heating and refrigerating systems are also studied. The energy analysis is conducted focusing on irreversibilities produced during energy conversion or transfer processes. A novel concept is introduced : the calculation of exergy destruction in real processes. Moreover a conference regarding Nuclear Energy is given at the end.

Outline

1. Overview on thermodynamic cycles and introduction of exergy analysis
2. Gas Turbine
3. Vapor cycle
4. Internal Combuction Engine
5. Refrigeration systems
6. Heat Pump.
7. Nuclear fuel Conference

Bibliography

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- RENAUD GICQUEL; « Systèmes Energétiques »; Les presses de l'Ecole des Mines de Paris, 2001, Tome 1 et Tome 2

- HIH SARAVANAMUTTOO, GFC ROGERS ET H COHEN; « Gas Turbine Theory»; PEARSON Prentice Hall, 2001, 5th edition

- VAN WYLEN, SONNTAG ET DESROCHERS; « Thermodynamique Appliquée»; Editions du Renouveau Pédagogique, 1992

- M.J. MORAN ET H.N. SHAPIRO; « Fundamentals of Engineering Thermodynamics»; John Wiley and Sons, 2004

- G. SARLOS, P.A. HALDI ET P. VERSTRAETE; « Systèmes Energétiques»; Presses Polytechniques et Universitaires Romandes, 2003

- Y.A. CENCEL ET M.A. BOLES; « Thermodynamics . _ '.An Engineering Approach »; MacGraw-Hill, 1998

Prerequisites

Applied Thermodynamics, Thermodynamics, turbomachinery

Learning outcomes

Learning outcomes	N	A	M	E	O
• ? To be abble to calculate the energy degradation during real elementary processes (compression/expansion, heat transfer, chemical reaction, ...)	✓	·	·	·	·
• - Dresser un bilan énergétique complet d'une installation industrielle - Dresser un bilan	·	·	✓	·	·
• ? To be abble to define a proper energy efficiency criterion to an energy conversion or transfer process	·	·	✓	·	·

Manager : Bruno AUVITY

Thermodynamics : First and Second Laws, Phase Equilibrium

Hours

Lect	Tut	PW	Proj	WP	Asst
15	17.25	7.5			20

Evaluation

3 evaluations :

- *1 DS*
- *TP*
- *CC*

Presentation

The basics of thermodynamics and energetics are fully established. The fundamental concepts are recalled. First and second laws are presented in details and illustrated on typical cases in to order to highlight and understand energy exchanges. Studied systems are pure substance under one or more phases but also coupled systems such as thermomechanical or thermoelectrical systems.

Outline

1-First Law

Magic Formula/From Matter to System/Internal Energy: within the System/Work and Heat: Exchanges with the Outside/Global and Elementary Formulations

2-Second Law

Magic Formula/Entropy/Variations: Why?/Consequences/Global and Elementary Formulations/Microscopic Interpretation, Disorder

3-Phase Equilibrium

Three Phases... and even more!/Chemical Potential and Equilibrium/Standard Functions/From One Equilibrium to Another/Stability

4-Thermodynamics Functions

From Calorimetric Coefficients/Maxwell Relations/Gibbs Function/Perfect Gas Application/Coupled Systems

Goals

At the end of the module, the aim is that students have clear ideas about energy transfers. Energy, internal energy or enthalpy are physically interpreted in relation to the state of matter in order to better understand them, to understand their meaning and to touch the hypotheses and limitations of the models. Energy exchanges in the form of work are analyzed from a mechanical point of vue, energy exchange in the form of heat from a thermal point of vue. Students have to well understand how conservative energy transforms itself in one form or another by conversions during evolutions.

Bibliography

J.-N. Foussard, E. Julien, S. Mathé, H. Debellefontaine, "Les bases de la thermodynamique", cours et exercices corrigés, Edition Dunod

M.J. Moran, H.N. Shapiro, "Fundamentals of Engineering Thermodynamics", John Wiley & Sons, Inc

Y.A. Cengel, M.A. Boles "Thermodynamics, An Engineering Approach", McGraw-Hill

R.E. Sonntag, C. Borgnakke, G.J. Van Wylen "Fundamentals of Thermodynamics", John Wiley & Sons, Inc

Prerequisites

Mathematics for the Engineer: Functions of Several Variables

Learning outcomes

Learning outcomes	N	A	M	E	O
• Be able to calculate an energy balance for a system during an evolution	·	·	✓	·	·
• Recognize and interpret reversible and irreversible transformations	·	·	✓	·	·
• Know some equations of state for real substance	✓	·	·	·	·
• Know pure substance and phase transformations	·	·	✓	·	·
• Be able to calculate energy exchanges for coupled systems	·	✓	·	·	·

Manager : Emilie GADOIN

Thermorheology

Hours

Lect	Tut	PW	Proj	WP	Asst
12	1.5				5

Evaluation

One evaluation : *1 DS*

Outline

1. Introduction to rheology
-Rheology and continuum mechanics
- Rheological phenomena
- Non Newtonian rheological behaviour in shear
2. Basics of continuum mechanics
- Stresses
- Deformation
-Conservation laws
- Constitutive relations
3.Viscometric flows
- Flow kinematics
-Controlled viscometric flows
- Unsteady shear flowe
- Extensional flows
- Experimental results
4. Concentrated and diluted fluids- Polymer molecules
-Dilute polymer solutions
- Constitutive laws for dilute polymer solutions
- Strong and weak flows
- Theory of suspensions
5. Thermo rheology
- Laminar flows
- Transitional flows
- Turbulent flows
6. Viscosimetry
- concepts
- Main types of viscometry
- Exemples
.Polymer melts .Polymer solutions .Thixotropic systems .Cosmetic products

Bibliography

- Roger I. Tanner ; « Engineering Rheology » ; Oxford Science Publications, 1988, Revised Edition
- J. Mark, K. Ngai, W. Graessley, L. Mandelkern, E. Samulski, J. Koenig & G. Wignall ; « Physical Properties of Polymers » ; Cambridge University Press, 2004, Third Edition
- N. Midoux ; « Mécanique et rhéologie des fluides en génie chimique » ; Technique et Documenation, Lavoisier, 1985

Prerequisites

- Calculus
  - Laminar thermal convection
  - Turbulent convection
  - Fluid dynamics

Learning outcomes

Learning outcomes	N	A	M	E	O
• Understand basic rheological phenomena and non Newtonian behaviour in shear	·	·	✓	·	·
• Understand the basics of thermo-rheology: laminar flows, transitional flows, turbulent flows	·	·	✓	·	·
• Understand the basics of viscometry	·	✓	·	·	·

Manager : Arthur LEVY

Training for Toeic

Hours

Lect	Tut	PW	Proj	WP	Asst
	18				

Evaluation

One evaluation : *CC*

Training for Toeic

Hours

Lect	Tut	PW	Proj	WP	Asst
	18				

Evaluation

One evaluation : *CC*

Transition Engineering and Interdisciplinarity S7

Hours

Lect	Tut	PW	Proj	WP	Asst
			32		

Evaluation

One evaluation : *Evaluation*

Manager : Bruno AUVITY

Transition Engineering and Interdisciplinarity S8

Hours

Lect	Tut	PW	Proj	WP	Asst
			32		

Evaluation

One evaluation : *Evaluation*

Manager : Bruno AUVITY

Turbomachinery

Hours

Lect	Tut	PW	Proj	WP	Asst
	19.5				17

Evaluation

2 evaluations :

- *1 DS*
- *CC*

Outline

1. Introduction - General overview of hydraulic turbomachineries. 2. Mass and energy conservation equations in open systems 3. Interaction of a machinery and a hydraulic system 4. Kinematics of turbomachinery 5. Thermodynamic theory of gas compression and expansion 6. Similarity laws for turbomachinery in incompressible regime 7. Particular operations of machinery (pumping limit, serie/parallel arrangement)

Goals

This course is focused on rotating machineries used in renewable (wind turbine), in ventilation, air conditionning and aeronautics (turboreactor). The students will get a physical understanding of turbomachinery operations and of the interaction between a machinery and the hydraulic system. At the end of the course, the students will be abble to perform the preliminary design of a rotating machinery.

Bibliography

- A.J. Smits ; « Physical Introduction to Fluid Mechanics » ; John Wiley and Sons, 2000
- Pierre Henry ; « Turbomachines Hydrauliques » ; Presses Polytechniques et Universitaires Romandes, 1992
- Michel Pluviose ; « Machines à fluides : Principes et fonctionnement » ; Ellipses, 2002
- Michel Pluviose ; « Ingenierie des turbomachines » ; Ellipses, 2003
- Renaud Gicquel ; « Systèmes Energétiques » ; Les presses de l'Ecole des Mines de Paris,

Prerequisites

- Fluid mechanics
- Applied thermodynamics
- thermodynamics

Learning outcomes

Learning outcomes	N	A	M	E	O
• To be abble to determine the operating point of a machinery on a given hydraulic system	·	·	✓	·	·
• To understand and model the energy transfer (kinetic energy, pressure energy, thermal energy, irreversible dissipation) in a rotating machinery	·	·	✓	·	·
• To be abble to do the preliminary design of rotor blades in a rotating machinery	·	·	✓	·	·

Manager : Bruno AUVITY

Ventilation and Air-conditionning Systems

Hours

Lect	Tut	PW	Proj	WP	Asst
9	9	4			12

Evaluation

2 evaluations :

- *CR Proj*
- *TP*

Outline

1. The moist air
- psychrometric chart theory
- Evolution of the basic constituents of HVAC system
- Drawing a complete transformation
- Dimensioning of a HVAC system (CTA)
- Reminders normative - legal
2. Air conditioning systems
- Classification
- technology
3. Air diffusion
- Network ventilation
. Constituents. design of a network. airflow Balancing
- Diffusers

Goals

This technical course relies on global knowledge of thermodynamics and fluid mechanics to enable the design of heat, ventilation and air conditioning (HVAC) systems. starting from the thermal loads of a building, defining in a previous course, the aim of these course is to present the basis of such HVAC systems, relying on moist air theory, and the different technology associated with this simple thermodynamic transformations (humidification/dehumidification/cooling/heating). the student could finally design a global HVAC facility, from the dimensioning of heat exchangers to the choice of the diffusers and the balancing of the air network.

Bibliography

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- J-L Cauchepin ; « La qualité de l'air soufflé : ventilation, climatisation, conditionnement de l'air » ; Les éditions parisiennes
- P. Jacquard, S. Sandre ; « La pratique de la climatisation » ; Dunod, PYC Edition, 2006
- J-L Cauchepin ; « Climatisation et conditionnement de l'air modernes » ; PYC Edition, 2000
- AICVF; « Guide Thématique n10 "Conception des installations de climatisation et de conditionnement de l'air" » ; Les éditions parisiennes, 1999
- Hermann Recknagel, Eberhard Sprenger, E.-R. Schramek ; « Le Recknagel - Manuel pratique du génie climatique » ; PYC Editions, 1995
- D. Palenzuela, J.B. Hoffmann ; « Diffusion de l'air en climatisation individuelle : guide pratique » ; COSTIC, 1994

Prerequisites

-heat transfer (conduction, convection, radiation)
- building energetics -applied thermodynamics -general thermodynamics

Learning outcomes

Learning outcomes	N	A	M	E	O
• to Choose a scenario of HVAC and to define the evolution of the air in the psychrometric chart	·	·	✓	·	·
• to caracterise the components of the HVAC system	·	·	✓	·	·
• to know the different HVAC technologies	·	✓	·	·	·

Manager : Christophe JOSSET