INSA INSTITUT NATIONAL DES SCIENCES APPLIQUÉES RENNES

**Academic year 2020/2021**

**Courses offered by the programme**

# Génie Mathématique (GM)

**Semester(s) : 7-8-9-10**

**Curricula are organized in groups of courses (Unités d'Enseignement (UE)), consisting of several courses (Eléments Constitutifs (EC)). An EC is a teaching module including lectures (cours magistraux (CM)), tutorials (travaux dirigés (TD)), laboratory work (travaux pratiques (TP)), projects (PR), conferences (CONF), personal work (TA) and possibly other pedagocial activities (DIV). Some internships (stages (ST)) are compulsory**

**Commonly used abbreviations**
**CM : Lectures**
**TD : Tutorials**
**TP : Laboratory Work**
**CONF : Conferences**
**TA : Personal Work**
**PR : Project**
**ST : Internship**
**DIV : Miscellaneous**

| Code | Libelle |
|---|---|
| ARO07-MSRS | Risk Analysis and Scoring |
| ARO07-MSSD | Stochastic Models of Dynamical Systems |
| ARO07-OHA | Hilbertian Tools and Applications |
| ARO07-RO | Operational research methods |
| ARO07-ST | Time Series |
| ARO08-AS | Statistical Learning |
| ARO08-OND | Nondifferentiable Optimization, Applications in data analysis |
| ARO08-PE | Design of Experiments |
| ARO08-PMAA | Advanced mathematical programming and applications |
| INF07-CRYPTO | Cryptography Engineering |

# List of courses with handout in English or that can be taught in English

| Hilbertian Tools and Applications | ARO07-OHA |
|---|---|
| Number of hours : 36.00 h | 3.50 ECTS credit |
| CM : 14.00 h, TD : 16.00 h, TP : 6.00 h | handout in English |
| Reference Teacher(s) : BRIANE MARC | |

**Objectives :**
This teaching delivers notions of Functional Analysis which are essential in mathematical engineering.

**Content :**
Inner product, Cauchy-Schwarz inequality.
Definition and examples of Hilbert spaces.
Theorem of the orthogonal projection.
The Riesz representation theorem.
The weak convergence in a Hilbert space.
Hilbert bases, Gram-Schmidt process.
Lp spaces.
The Schwartz space and the tempered distributions.
Sobolev spaces.
Minimization of a convex functional.
Elliptic boundary value problems.
Introduction to wavelets.

**Bibliography :**
H. Brezis. Functional Analysis, Sobolev Spaces and Partial Differential Equations. Springer, New York, 2011.
J. M. Bony. Cours d'analyse, théorie des distributions et analyse de Fourier. Édition de l'école Polytechnique, 2001.
B. Maury. Analyse fonctionnelle, exercices et problèmes corrigés. Ellipse, 2004.
W. Rudin, Real and complex analysis, Third edition, McGraw-Hill Book Co., New York, 1987.
M. Willem, Analyse harmonique réelle, Collection Méthodes, Hermann, Paris, 1995.

**Requirements :**
This teaching needs the knowledge of the basic mathematics of the Bachelor.

**Organisation :**

**Evaluation :**
One written test (3/4) and one test on tutorial practises or project (1/4).

**Target :**

| Stochastic Models of Dynamical Systems | ARO07-MSSD |
|---|---|
| Number of hours : 42.00 h | 3.50 ECTS credit |
| CM : 18.00 h, TD : 14.00 h, TP : 10.00 h | handout in English |
| Reference Teacher(s) : LEDOUX JAMES | |

**Objectives :**
Objectives of this course are to make students acquainted with stochastic models of dynamical systems together with their simulation and numerical implementation. Students are aware of various application areas through the examples.

**Content :**
Martingale
Discrete-time martingale. Asymptotic convergence. Applications
Standard Markov processes
Poisson process. Markov jump processes
Applications to stochastic operation research
Introduction to stochastic differential equations (SDE)
Brownian motion
Diffusions
Examples in (biological, biomedical, financial) systems engineering
Numerical methods for SDE
Practical implementation with Matlab/R

**Bibliography :**
D. Foata and A. Fuchs. Processus stochastique : processus de Poisson, chaînes de Markov et martingales. Dunod, 2002.
F. Comets and T. Meyre. Calcul stochastique et modèles de diffusions. Dunod, 2006.
P. Kloeden, E. Peter, E. Platen and H. Schurz. Numerical Solution of SDE Through Computer Experiments. Springer, 2003.
T. Rolski, H. Schmidli, V. Schmidt and J. L. Teugels. Stochastic Processes for Insurance and Finance. Wiley & Sons, 1999.
Wai-Yuan Tan. Stochastic Models with Applications to Genetics, Cancer, AIDS and Other Biomedical Systems (2nd edition). World Scientific, 2015.

**Requirements :**
Courses of “Introduction aux probability” (STPI-2nd), “Tools for stochastic modelling” (TC-3rd), “Probability” (ARO05), “Markov models” (ARO06).

**Organisation :**

**Evaluation :**
Two written examinations (2/3) and a practical examination and/or project (1/3).

**Target :**

| Risk Analysis and Scoring | ARO07-MSRS |
|---|---|
| Number of hours : 36.00 h | 3.50 ECTS credit |
| CM : 20.00 h, TP : 16.00 h | handout in English |
| Reference Teacher(s) : DUPUY JEAN-FRANCOIS | |

**Objectives :**
The objective of this course is to make students acquainted with fundamental tools for risk analysis and scoring and with related SAS/R skills.

**Content :**
Regression models for binary data
Statistical inference in the logistic model
Variable selection and model validation in the logistic model
Confusion matrix and ROC curve
Overdispersed data
Zero-inflated regression models
Practical with SAS, R

**Bibliography :**
J.-F. Dupuy Méthodes statistiques pour l'analyse de données de comptage sur-dispersées. ISTE Ltd, London, UK. To appear.
G.M. Fitzmaurice, N.M. Laird, J.H. Ware. Applied longitudinal analysis. Wiley, 2011.
J.M. Hilbe. Logistic regression models. Chapman & Hall, 2009.
C. Robert, G. Casella. Méthodes de Monte-Carlo avec R. Springer-Verlag, 2011.
S. Tufféry. Data mining et statistique décisionnelle. Technip, 2012.

**Requirements :**
Courses of “Introduction to mathematical softwares” and “Inferential statistics” (3rd year).

**Organisation :**

**Evaluation :**
One written examination (2/3) and a practical examination and/or project (1/3).

**Target :**

| Time Series | ARO07-ST |
|---|---|
| Number of hours : 30.00 h | 3.00 ECTS credit |
| CM : 8.00 h, TD : 10.00 h, TP : 12.00 h | handout in English |
| Reference Teacher(s) : DUPUY JEAN-FRANCOIS | |

**Objectives :**
The aim of this course is to provide fundamentals tools for the analysis of univariate time series and associated skills in R/SAS.

**Content :**
Basic tools for time series analysis : moving average, exponential smoothing
Discrete-time stationary processes : stationarity, autocorrelation function and partial autocorrelation function, ARMA processes and related statistical inference
SARIMA models : identification, estimation, validation
Unit root test
Practical skills with SAS, R.

**Bibliography :**
C. Gouriéroux. Séries temporelles et modèles dynamiques (2ème éd). Economica, 1995.
J.D. Hamilton. Time series analysis. Princeton University Press, 1994.
P.J. Brockwell, R.A. Davis. Times series: theory and methods. Springer, 1991.

**Requirements :**
Courses of “Probability”, “Introduction to mathematical softwares” and “Inferential statistics” of 3rd year.

**Organisation :**

**Evaluation :**
Project.

**Target :**

| Object Oriented Programming in C++ | ARO07-POO |
|---|---|
| Number of hours : 28.00 h | 2.50 ECTS credit |
| CM : 14.00 h, TP : 14.00 h | |
| Reference Teacher(s) : ANQUETIL ERIC | |

**Objectives :**
Object-oriented programming is a powerful tool to cope with the development of real applications. It helps to define projects with an effective monitoring of the different phases of evolution. This course emphasizes the fundamental principles associated with object-oriented programming. It is performed in C++ and introduce all the fundamental concepts of object programming.

**Content :**
# Object-oriented programming in C++.
* Notion of object in C++: Construction of objects, Interfaces, Encapsulation, etc.
* Memory management: Dynamic memory allocation, Destructor, Assignment statement…
* Basic elements of C++: Input/Output management, String, etc.
* Object conception in C++: Aggregation, Inheritance, Polymorphism, Access control, etc.
* Multiple inheritance
* Generic programming, Template class.
* Internal class.
* Standard Template Library (STL),
* Run Time Type Identification (RTTI)
* Exceptions handling.
* Introduction to IHM programming (DotNET, wpf and MVVM…)

**Bibliography :**
G. Booch. Conception orientée objets et applications. Addison-Wesley, 1996.
B. Stroustrup. The C++ programming language (third edition). Addison-Wesley, 1997.

**Requirements :**
Basic understanding of algorithmic.
C programming
Optional: Basic object-oriented programming in Java (STPI 2A).

**Organisation :**
Revision of class notes (1h per week)

**Evaluation :**
A practical TP exam with several questions on the course.

**Target :**

| Operational research methods | ARO07-RO |
|---|---|
| Number of hours : 36.00 h | 3.50 ECTS credit |
| CM : 10.00 h, TD : 12.00 h, TP : 14.00 h | handout in English |
| Reference Teacher(s) : OMER JEREMY | |

**Objectives :**
This course is a general presentation of Operations research techniques. The main objectives are:
• To master the most important methods of operational research
• To be able to analyze a practical problem, identify its variables, model it as mathematical program, propose and apply a solution method and discuss the results
• To know and recognize the most classical problems of operational research

**Content :**
• Introduction to combinatorial optimization
• Modeling a practical problem using integer programming
• Solving an integer program with the branch-and-bound algorithm
• Linear and Lagrangian relaxations; duality in integer programming
• Basic polyhedral theory and cutting planes algorithms
• Application to classical problems of operational research stated as practical cases
• Modeling and solution of problems using the modeling language Python PuLP and the optimization libraries Gurobi and Coin CBC.
• Implementation of solution algorithm using Python language

**Bibliography :**
[1] A. Billionnet, Optimisation discrète : de la modélisation à la résolution par des logiciels de programmation mathématique. 2007.
[2] M. Minoux, Programmation mathématique : théorie et algorithmes, 2e édition. 2008.
[3] G. L. Nemhauser and L. A. Wolsey, “Integer and Combinatorial Optimization,” 1999
[4] R. J. Vanderbei, Linear Programming - Foundations and Extensions, vol. 114. Boston, MA: Springer US, 2008.
[5] L. A. Wolsey, Integer programming. 1998

**Requirements :**
First and second year courses of linear algebra, courses of "Optimization", "Discrete optimization" and "Numerical Analysis" (3rd year).

**Organisation :**

**Evaluation :**
One exam (50 %), one Python project (40 %) and two practical works (10 %)

**Target :**

| Interdisciplinary Project | ARO07-PI |
|---|---|
| Number of hours : 36.00 h | 3.50 ECTS credit |
| EP : 36.00 h | |
| Reference Teacher(s) : MONIER LAURENT | |

**Objectives :**
The objective of this project is to make students familiar with its future professional environment. They must manage mathematical modelling in another scientific disciplinary framework. Thus, the progress of the project is ensured in collaboration with a teacher of another department (EII, GCU, GMA, INFO, SGM, SRC). Additional learning outcomes are to manage a collaborative project and to find relevant bibliographic resources.

**Content :**
From the proposal by a department (EII, GCU, GMA, INFO, SGM, SRC), the student must produce a bibliography, a written report and an oral presentation.

**Bibliography :**

**Requirements :**

**Organisation :**

**Evaluation :**
a written report and an oral presentation

**Target :**

| Business Seminar | ARO07-SE |
|---|---|
| Number of hours : 24.00 h | 1.00 ECTS credit |
| CONF : 24.00 h | |
| Reference Teacher(s) : OMER JEREMY | |

**Objectives :**
This module is an open forum for stakeholders of the business world. It covers all semesters of the engineering curriculum and aims at providing the students a broad-spectrum engineering culture. This module will constitute a unique opportunity for students to discover the different career profiles of mathematical engineering. Through this module, the students will also acquire some useful technical, managerial and juridical skills and a solid operational expertise. Finally, this module will help the students raising their awareness to the challenges of sustainable development and to the societal aspects of their future profession of engineer.

**Content :**
In the 4th year, the module will offer (among others) :
- Specific software training ;
- some awareness to specific technical issues related to the profession of mathematical engineer (such as scoring, pricing...).

**Bibliography :**

**Requirements :**

**Organisation :**

**Evaluation :**
The assessment is based on some report delivery.

**Target :**

| English | HUM07-ANGL |
|---|---|
| Number of hours : 28.00 h | 2.00 ECTS credit |
| TD : 28.00 h | |
| Reference Teacher(s) : RANNOU ISABELLE | |

**Objectives :**
Acquiring the required skills for working in a firm as an engineer. Reaching the required level (B2) is compulsory in order to graduate.

**Content :**
-Learning by doing:
The student will have to be able to talk and listen, write documents while showing he/she can solve problems, reason, convince and demonstrate in an articulate manner.
-Expressing oneself accurately and fluently.
The student will engage in activities requiring creative and reactive skills (such as debates, role-plays, individual oral presentations using PowerPoint, projects), which will be based on scientific topics and current events.
-Writing CVs and cover letters
-Scientific English
-Discovering the professional world in an international context
-Preparing for the TOEIC (during the second semester, a specific ¿Toeic Booster¿ course will be available)

**Bibliography :**
- Oxford Advanced learners¿ Dictionary
- English Grammar in Use (Cambridge University Press)

**Requirements :**
1st, 2nd and 3rd year English courses (or equivalent)

**Organisation :**
Each class lasts two hours and most classrooms are equipped with video and audio. A multimedia language lab and computer rooms are also available and make it possible for the students to work in a stimulating environment. Our teaching resources include press articles, audio and video documents (TV reports, extracts from films and series). We also use the Internet.
Regular personal work is obviously required. The student must be curious and practise English outside the classroom as well.

**Evaluation :**
One two-hour written exam.

**Target :**

| Entrepreneurship and Innovation | HUM07-EI |
|---|---|
| Number of hours : 48.00 h | 3.00 ECTS credit |
| CM : 24.00 h, TD : 24.00 h | |
| Reference Teacher(s) : GOURRET FANNY | |

**Objectives :**

**Content :**

**Bibliography :**

**Requirements :**

**Organisation :**

**Evaluation :**

**Target :**

| Sport and physical education | HUM07-EPS |
|---|---|
| Number of hours : 24.00 h | 1.00 ECTS credit |
| TD : 24.00 h | |
| Reference Teacher(s) : LE LAGADEC PIERRE | |

**Objectives :**
Team work, discovery of one's capabilities, communication, invention and management responsibilities.

**Content :**
Choice of two activities from a menu. Adapting to destabilising situations and taking responsibility when risk is involved.
Speaking to groups. Leading group stretching exercises. Indoors: Rock climbing or badminton in teams. Outdoors: C.O or
Kayak or golf

**Bibliography :**
Several specialized books are available to the students at the library. Links to internet sites are given on the EPS website.

**Requirements :**

**Organisation :**

**Evaluation :**
Evaluation is based upon student participation, progress and acquisition. The student is asked to criticise his own progress with respect to the objectives of the course. The ability to be self-critical leads to self-discovery. Sharing this knowledge with a group reinforces one's confidence.

**Target :**

| Stages 3 GM | ARO07-STA3-2 |
|---|---|
| Number of hours : 240.00 h | 2.00 ECTS credit |
| DIV : 0.00 h | |
| Reference Teacher(s) : | |

**Objectives :**

**Content :**

**Bibliography :**

**Requirements :**

**Organisation :**

**Evaluation :**

**Target :**

**Semestre 7**

**Parcours Recherche**

| | | | | |
|---|---|---|---|---|
| **1** | **ARO07-MA** | | **APPLIED MATHEMATICS** | **7.00** |
| | ARO07-OHA | O | Hilbertian Tools and Applications | 3.50 |
| | ARO07-MSSD | O | Stochastic Models of Dynamical Systems | 3.50 |
| **2** | **ARO07-MODS** | | **STATISTICAL MODELLING** | **6.50** |
| | ARO07-MSRS | O | Risk Analysis and Scoring | 3.50 |
| | ARO07-ST | O | Time Series | 3.00 |
| **3** | **ARO07-INFOS** | | **SCIENTIFIC COMPUTING AND DISCRETE MATHEMATICS** | **6.00** |
| | ARO07-POO | O | Object Oriented Programming in C++ | 2.50 |
| | ARO07-RO | O | Operational research methods | 3.50 |
| **4** | **ARO07-SEMP-2** | | **SEMINAR AND PROJECT** | **4.50** |
| | ARO07-PR1 | O | Research Project | 3.50 |
| | ARO07-SE | O | Business Seminar | 1.00 |
| **5** | **HUM07** | | **Non-scientific syllabus S7** | **6.00** |
| | HUM07-ANGL | O | English | 2.00 |
| | HUM07-EI | O | Entrepreneurship and Innovation | 3.00 |
| | HUM07-EPS | O | Sport and physical education | 1.00 |

O = compulsary, C= in choice , F= optional

| Hilbertian Tools and Applications | ARO07-OHA |
|---|---|
| Number of hours : 36.00 h | 3.50 ECTS credit |
| CM : 14.00 h, TD : 16.00 h, TP : 6.00 h | handout in English |
| Reference Teacher(s) : BRIANE MARC | |

**Objectives :**
This teaching delivers notions of Functional Analysis which are essential in mathematical engineering.

**Content :**
Inner product, Cauchy-Schwarz inequality.
Definition and examples of Hilbert spaces.
Theorem of the orthogonal projection.
The Riesz representation theorem.
The weak convergence in a Hilbert space.
Hilbert bases, Gram-Schmidt process.
Lp spaces.
The Schwartz space and the tempered distributions.
Sobolev spaces.
Minimization of a convex functional.
Elliptic boundary value problems.
Introduction to wavelets.

**Bibliography :**
H. Brezis. Functional Analysis, Sobolev Spaces and Partial Differential Equations. Springer, New York, 2011.
J. M. Bony. Cours d'analyse, théorie des distributions et analyse de Fourier. Édition de l'école Polytechnique, 2001.
B. Maury. Analyse fonctionnelle, exercices et problèmes corrigés. Ellipse, 2004.
W. Rudin, Real and complex analysis, Third edition, McGraw-Hill Book Co., New York, 1987.
M. Willem, Analyse harmonique réelle, Collection Méthodes, Hermann, Paris, 1995.

**Requirements :**
This teaching needs the knowledge of the basic mathematics of the Bachelor.

**Organisation :**

**Evaluation :**
One written test (3/4) and one test on tutorial practises or project (1/4).

**Target :**

| Stochastic Models of Dynamical Systems | ARO07-MSSD |
|---|---|
| Number of hours : 42.00 h | 3.50 ECTS credit |
| CM : 18.00 h, TD : 14.00 h, TP : 10.00 h | handout in English |
| Reference Teacher(s) : LEDOUX JAMES | |

**Objectives :**
Objectives of this course are to make students acquainted with stochastic models of dynamical systems together with their simulation and numerical implementation. Students are aware of various application areas through the examples.

**Content :**
Martingale
Discrete-time martingale. Asymptotic convergence. Applications
Standard Markov processes
Poisson process. Markov jump processes
Applications to stochastic operation research
Introduction to stochastic differential equations (SDE)
Brownian motion
Diffusions
Examples in (biological, biomedical, financial) systems engineering
Numerical methods for SDE
Practical implementation with Matlab/R

**Bibliography :**
D. Foata and A. Fuchs. Processus stochastique : processus de Poisson, chaînes de Markov et martingales. Dunod, 2002.
F. Comets and T. Meyre. Calcul stochastique et modèles de diffusions. Dunod, 2006.
P. Kloeden, E. Peter, E. Platen and H. Schurz. Numerical Solution of SDE Through Computer Experiments. Springer, 2003.
T. Rolski, H. Schmidli, V. Schmidt and J. L. Teugels. Stochastic Processes for Insurance and Finance. Wiley & Sons, 1999.
Wai-Yuan Tan. Stochastic Models with Applications to Genetics, Cancer, AIDS and Other Biomedical Systems (2nd edition). World Scientific, 2015.

**Requirements :**
Courses of “Introduction aux probability” (STPI-2nd), “Tools for stochastic modelling” (TC-3rd), “Probability” (ARO05), “Markov models” (ARO06).

**Organisation :**

**Evaluation :**
Two written examinations (2/3) and a practical examination and/or project (1/3).

**Target :**

| Risk Analysis and Scoring | ARO07-MSRS |
|---|---|
| Number of hours : 36.00 h | 3.50 ECTS credit |
| CM : 20.00 h, TP : 16.00 h | handout in English |
| Reference Teacher(s) : DUPUY JEAN-FRANCOIS | |

**Objectives :**
The objective of this course is to make students acquainted with fundamental tools for risk analysis and scoring and with related SAS/R skills.

**Content :**
Regression models for binary data
Statistical inference in the logistic model
Variable selection and model validation in the logistic model
Confusion matrix and ROC curve
Overdispersed data
Zero-inflated regression models
Practical with SAS, R

**Bibliography :**
J.-F. Dupuy Méthodes statistiques pour l'analyse de données de comptage sur-dispersées. ISTE Ltd, London, UK. To appear.
G.M. Fitzmaurice, N.M. Laird, J.H. Ware. Applied longitudinal analysis. Wiley, 2011.
J.M. Hilbe. Logistic regression models. Chapman & Hall, 2009.
C. Robert, G. Casella. Méthodes de Monte-Carlo avec R. Springer-Verlag, 2011.
S. Tufféry. Data mining et statistique décisionnelle. Technip, 2012.

**Requirements :**
Courses of “Introduction to mathematical softwares” and “Inferential statistics” (3rd year).

**Organisation :**

**Evaluation :**
One written examination (2/3) and a practical examination and/or project (1/3).

**Target :**

| Time Series | ARO07-ST |
|---|---|
| Number of hours : 30.00 h | 3.00 ECTS credit |
| CM : 8.00 h, TD : 10.00 h, TP : 12.00 h | handout in English |
| Reference Teacher(s) : DUPUY JEAN-FRANCOIS | |

**Objectives :**
The aim of this course is to provide fundamentals tools for the analysis of univariate time series and associated skills in R/SAS.

**Content :**
Basic tools for time series analysis : moving average, exponential smoothing
Discrete-time stationary processes : stationarity, autocorrelation function and partial autocorrelation function, ARMA processes and related statistical inference
SARIMA models : identification, estimation, validation
Unit root test
Practical skills with SAS, R.

**Bibliography :**
C. Gouriéroux. Séries temporelles et modèles dynamiques (2ème éd). Economica, 1995.
J.D. Hamilton. Time series analysis. Princeton University Press, 1994.
P.J. Brockwell, R.A. Davis. Times series: theory and methods. Springer, 1991.

**Requirements :**
Courses of “Probability”, “Introduction to mathematical softwares” and “Inferential statistics” of 3rd year.

**Organisation :**

**Evaluation :**
Project.

**Target :**

| Object Oriented Programming in C++ | ARO07-POO |
|---|---|
| Number of hours : 28.00 h | 2.50 ECTS credit |
| CM : 14.00 h, TP : 14.00 h | |
| Reference Teacher(s) : ANQUETIL ERIC | |

**Objectives :**
Object-oriented programming is a powerful tool to cope with the development of real applications. It helps to define projects with an effective monitoring of the different phases of evolution. This course emphasizes the fundamental principles associated with object-oriented programming. It is performed in C++ and introduce all the fundamental concepts of object programming.

**Content :**
# Object-oriented programming in C++.
* Notion of object in C++: Construction of objects, Interfaces, Encapsulation, etc.
* Memory management: Dynamic memory allocation, Destructor, Assignment statement…
* Basic elements of C++: Input/Output management, String, etc.
* Object conception in C++: Aggregation, Inheritance, Polymorphism, Access control, etc.
* Multiple inheritance
* Generic programming, Template class.
* Internal class.
* Standard Template Library (STL),
* Run Time Type Identification (RTTI)
* Exceptions handling.
* Introduction to IHM programming (DotNET, wpf and MVVM…)

**Bibliography :**
G. Booch. Conception orientée objets et applications. Addison-Wesley, 1996.
B. Stroustrup. The C++ programming language (third edition). Addison-Wesley, 1997.

**Requirements :**
Basic understanding of algorithmic.
C programming
Optional: Basic object-oriented programming in Java (STPI 2A).

**Organisation :**
Revision of class notes (1h per week)

**Evaluation :**
A practical TP exam with several questions on the course.

**Target :**

| Operational research methods | ARO07-RO |
|---|---|
| Number of hours : 36.00 h | 3.50 ECTS credit |
| CM : 10.00 h, TD : 12.00 h, TP : 14.00 h | handout in English |
| Reference Teacher(s) : OMER JEREMY | |

**Objectives :**
This course is a general presentation of Operations research techniques. The main objectives are:
• To master the most important methods of operational research
• To be able to analyze a practical problem, identify its variables, model it as mathematical program, propose and apply a solution method and discuss the results
• To know and recognize the most classical problems of operational research

**Content :**
• Introduction to combinatorial optimization
• Modeling a practical problem using integer programming
• Solving an integer program with the branch-and-bound algorithm
• Linear and Lagrangian relaxations; duality in integer programming
• Basic polyhedral theory and cutting planes algorithms
• Application to classical problems of operational research stated as practical cases
• Modeling and solution of problems using the modeling language Python PuLP and the optimization libraries Gurobi and Coin CBC.
• Implementation of solution algorithm using Python language

**Bibliography :**
[1] A. Billionnet, Optimisation discrète : de la modélisation à la résolution par des logiciels de programmation mathématique. 2007.
[2] M. Minoux, Programmation mathématique : théorie et algorithmes, 2e édition. 2008.
[3] G. L. Nemhauser and L. A. Wolsey, “Integer and Combinatorial Optimization,” 1999
[4] R. J. Vanderbei, Linear Programming - Foundations and Extensions, vol. 114. Boston, MA: Springer US, 2008.
[5] L. A. Wolsey, Integer programming. 1998

**Requirements :**
First and second year courses of linear algebra, courses of "Optimization", "Discrete optimization" and "Numerical Analysis" (3rd year).

**Organisation :**

**Evaluation :**
One exam (50 %), one Python project (40 %) and two practical works (10 %)

**Target :**

| Research Project | ARO07-PR1 |
|---|---|
| Number of hours : 36.00 h | 3.50 ECTS credit |
| EP : 36.00 h | |
| Reference Teacher(s) : LEDOUX JAMES | |

**Objectives :**
The objective is to propose a discovery of the profession of researcher and its professional environment in an academic or industrial context.

**Content :**
A project exploring one of the themes favored by the student will be proposed by a researcher from an academic/industrial laboratory in Rennes. It is adapted to the skills acquired until then by the student.
It is requested to conduct an interview with a researcher from at least three different laboratories. The project can be accompanied by any initiative of discovery of the world of research (visit of academic or industrial laboratory, participation in meetings of follow-up of research projects, process of publication of a scientific article ...)

**Bibliography :**
Each project is based on a specific bibliographic study.

**Requirements :**
36h are reserved in the timetable of the semester. Each session is an opportunity to discuss with his tutor.

**Organisation :**

**Evaluation :**
A report of not more than 25 pages which can be written in English. A 20 minutes defense in English.

**Target :**
3 students with strong academic results

| Business Seminar | ARO07-SE |
|---|---|
| Number of hours : 24.00 h | 1.00 ECTS credit |
| CONF : 24.00 h | |
| Reference Teacher(s) : OMER JEREMY | |

**Objectives :**
This module is an open forum for stakeholders of the business world. It covers all semesters of the engineering curriculum and aims at providing the students a broad-spectrum engineering culture. This module will constitute a unique opportunity for students to discover the different career profiles of mathematical engineering. Through this module, the students will also acquire some useful technical, managerial and juridical skills and a solid operational expertise. Finally, this module will help the students raising their awareness to the challenges of sustainable development and to the societal aspects of their future profession of engineer.

**Content :**
In the 4th year, the module will offer (among others) :
- Specific software training ;
- some awareness to specific technical issues related to the profession of mathematical engineer (such as scoring, pricing...).

**Bibliography :**

**Requirements :**

**Organisation :**

**Evaluation :**
The assessment is based on some report delivery.

**Target :**

| English | HUM07-ANGL |
|---|---|
| Number of hours : 28.00 h | 2.00 ECTS credit |
| TD : 28.00 h | |
| Reference Teacher(s) : RANNOU ISABELLE | |

**Objectives :**
Acquiring the required skills for working in a firm as an engineer. Reaching the required level (B2) is compulsory in order to graduate.

**Content :**
-Learning by doing:
The student will have to be able to talk and listen, write documents while showing he/she can solve problems, reason, convince and demonstrate in an articulate manner.
-Expressing oneself accurately and fluently.
The student will engage in activities requiring creative and reactive skills (such as debates, role-plays, individual oral presentations using PowerPoint, projects), which will be based on scientific topics and current events.
-Writing CVs and cover letters
-Scientific English
-Discovering the professional world in an international context
-Preparing for the TOEIC (during the second semester, a specific ¿Toeic Booster¿ course will be available)

**Bibliography :**
- Oxford Advanced learners¿ Dictionary
- English Grammar in Use (Cambridge University Press)

**Requirements :**
1st, 2nd and 3rd year English courses (or equivalent)

**Organisation :**
Each class lasts two hours and most classrooms are equipped with video and audio. A multimedia language lab and computer rooms are also available and make it possible for the students to work in a stimulating environment. Our teaching resources include press articles, audio and video documents (TV reports, extracts from films and series). We also use the Internet.
Regular personal work is obviously required. The student must be curious and practise English outside the classroom as well.

**Evaluation :**
One two-hour written exam.

**Target :**

| Entrepreneurship and Innovation | HUM07-EI |
|---|---|
| Number of hours : 48.00 h | 3.00 ECTS credit |
| CM : 24.00 h, TD : 24.00 h | |
| Reference Teacher(s) : GOURRET FANNY | |

**Objectives :**

**Content :**

**Bibliography :**

**Requirements :**

**Organisation :**

**Evaluation :**

**Target :**

| Sport and physical education | HUM07-EPS |
|---|---|
| Number of hours : 24.00 h | 1.00 ECTS credit |
| TD : 24.00 h | |
| Reference Teacher(s) : LE LAGADEC PIERRE | |

**Objectives :**
Team work, discovery of one's capabilities, communication, invention and management responsibilities.

**Content :**
Choice of two activities from a menu. Adapting to destabilising situations and taking responsibility when risk is involved.
Speaking to groups. Leading group stretching exercises. Indoors: Rock climbing or badminton in teams. Outdoors: C.O or
Kayak or golf

**Bibliography :**
Several specialized books are available to the students at the library. Links to internet sites are given on the EPS website.

**Requirements :**

**Organisation :**

**Evaluation :**
Evaluation is based upon student participation, progress and acquisition. The student is asked to criticise his own progress with respect to the objectives of the course. The ability to be self-critical leads to self-discovery. Sharing this knowledge with a group reinforces one's confidence.

**Target :**

**Semestre 8**

**Parcours Formation initiale Génie Mathématique**

| | | | | |
|---|---|---|---|---|
| **1** | **ARO08-INFOS** | | **SCIENTIFIC COMPUTING AND DISCRETE MATHEMATICS** | **7.00** |
| | ARO08-CHP | O | High Performance Computing | 2.00 |
| | ARO08-MERN | O | Modélisation par EDP et Résolution numérique | 3.00 |
| | ARO08-PMAA | O | Advanced mathematical programming and applications | 2.00 |
| **2** | **ARO08-SN** | | **COMPUTATIONAL SCIENCES** | **6.00** |
| | ARO08-PE | O | Design of Experiments | 2.00 |
| | ARO08-AS | O | Statistical Learning | 2.50 |
| | ARO08-OND | O | Nondifferentiable Optimization, Applications in data analysis | 2.00 |
| | ARO08-OGD | O | Large-Scale Optimization | 2.00 |
| **3** | **ARO08-SEMP** | | **SEMINAR AND PROJECT** | **3.00** |
| | ARO08-BE | O | Engineering Practical and Realistic Study | 2.50 |
| | ARO08-SE | O | Business Seminar | 0.50 |
| **4** | **ARO08-STAGE** | | **INTERNSHIP** | **8.00** |
| | ARO08-STAGE08 | O | Internship | 8.00 |
| **5** | **HUM08** | | **Non-scientific syllabus S8** | **6.00** |
| | HUM08-ANGL | O | English | 2.00 |
| | HUM08-ECO | O | Economy and Management | 1.00 |
| | HUM08-SHES1 | O | Engineer & Society - M1 | 1.00 |
| | HUM08-SHES2 | O | Engineer & Society - M2 | 1.00 |
| | HUM08-EPS | O | Sport and Physical Education | 1.00 |
| **6** | **DEIF2-MOB24-GM** | | **PROJET RECHERCHE MOBILITE ENTRANTE 24 crédits** | **24.00** |
| | DEIF2-MOB24-GM | C | Projet de recherche pour la mobilité entrante 24 créduts | 24.00 |

O = compulsary, C= in choice , F= optional

| High Performance Computing | ARO08-CHP |
|---|---|
| Number of hours : 36.00 h | 2.00 ECTS credit |
| CM : 10.00 h, TD : 6.00 h, TP : 20.00 h | |
| Reference Teacher(s) : PAZAT JEAN-LOUIS | |

**Objectives :**
The aim of this course is to provide the basic knowledge about High Performance Tools and programming techniques. We put emphasis both on using standard multicore architectures of desktop machines and on programming large clusters such at Top 500 machines.

**Content :**
Performance, complexity, speed-up
Overview of high performance computer architectures
Parallel Programming
Some models : map Reduce (Hadoop), multithreading (PThreads, OpenMP), introduction to the SIMD model, Message Passing (MPI).

**Bibliography :**
R. Chandra, R. Menon, L. Dagum, D. Kohr, D. Maydan, J. McDonald. Parallel Programming in OpenMP. Morgan Kaufmann, 2000.
T. Rauber, G. Rünger. Parallel Programming: for Multicore and Cluster Systems. 2nd edition 2013.
W. Gropp, E. Lusk, A. Skjellum. Using MPI: Portable Parallel Programming with the Message-Passing Interface. MIT Press, 1999.
W. Gropp, E. Lusk, R. Thakur. Using MPI-2. MIT Press, 1999.

**Requirements :**
Unix basic knowledge, C-programming knowledge.

**Organisation :**

**Evaluation :**
One written examination

**Target :**

| Modélisation par EDP et Résolution numérique | ARO08-MERN |
|---|---|
| Number of hours : 42.00 h | 3.00 ECTS credit |
| | |
| Reference Teacher(s) : | |

**Objectives :**

**Content :**

**Bibliography :**

**Requirements :**

**Organisation :**

**Evaluation :**

**Target :**

| Advanced mathematical programming and applications | ARO08-PMAA |
|---|---|
| Number of hours : 26.00 h | 2.00 ECTS credit |
| CM : 10.00 h, TD : 6.00 h, TP : 10.00 h | handout in English |
| Reference Teacher(s) : ARSLAN AYSE NUR | |

**Objectives :**
This course is a presentation of advanced mathematical programming techniques that are commonly used in the industry and academia to solve challenging problems. The main objectives are:
• To master the most commonly used methods of mathematical programming and understand the challenges behind their efficient implementation and use,
• To understand how these methods are applied to the most well-known and challenging problems encountered in the industry,
• To gain the ability to develop and implement such techniques to newly encountered problems.

**Content :**
• Introduction to dynamic programming,
• Dantzig-Wolfe decomposition and column generation,
• Branch-and-Price algorithm and its efficient implementation,
• Branch-and-Price applications: cutting stock, vehicle routing and bin-packing,
• Benders decomposition and its efficient implementation,
• Benders decomposition applications: facility location, network design,
• Modeling and solution of problems using the modeling language JuMP and the optimization libraries CPLEX, Gurobi, Coin CBC, etc.
• Implementation of solution algorithms using Julia language

**Bibliography :**
[1] Vanderbeck, François, and Laurence A. Wolsey. "Reformulation and decomposition of integer programs." 50 Years of Integer Programming 1958-2008. Springer, Berlin, Heidelberg, 2010. 431-502.
[2] M. Minoux, Programmation mathématique?: théorie et algorithmes, 2e édition. 2008.
[3] G. L. Nemhauser and L. A. Wolsey, “Integer and Combinatorial Optimization,” 1999
[4] L. A. Wolsey, Integer programming. 1998

**Requirements :**
First and second year courses of linear algebra, courses of "Optimization", "Discrete optimization", “Operations Research” and "Numerical Analysis" (3rd year).

**Organisation :**

**Evaluation :**
One exam (50 %), one Julia project (40 %) and one homework (10 %)

**Target :**
Engineering students with a background in applied mathematics.

| Design of Experiments | ARO08-PE |
|---|---|
| Number of hours : 28.00 h | 2.00 ECTS credit |
| CM : 10.00 h, TD : 12.00 h, TP : 6.00 h | handout in English |
| Reference Teacher(s) : CHAGNEAU PIERRETTE | |

**Objectives :**
This course is intended to familiarize students with experimental design methodology. At the end of the course, students will have a knowledge of different possible classes of experimental designs. They should be able to design an experiment and to analyze the obtained results with appropriate statistical methods.

**Content :**
One-way ANOVA, Two-way ANOVA with replication
Introduction to experimental design methodology
Factorial designs
Fractional factorial designs
Response surface designs
Design for mixture experiments

**Bibliography :**
J.-M. Azaïs, J.-M. Bardet. Le modèle linéaire par l'exemple. Dunod, 2005.
J.J. Droesbeke, J. Fine, G. Saporta. Plans d'expériences : Applications à l'entreprise. Editions Technip, 1997.
J. Goupy, L. Creighton. Introduction aux plans d'expériences. Dunod, 3ème édition, 2006.
J. Goupy. Plans d'expériences pour surfaces de réponse. Dunod, 1999.
W. Tinsson. Plans d'expériences : constructions et analyses statistiques. Springer, 2010.

**Requirements :**
Algebra courses from the undergraduate program of INSA (years 1-2) or equivalent skills.
Linear regression models
Introduction to mathematical software

**Organisation :**

**Evaluation :**
One written examination of 2h

**Target :**

| Statistical Learning | ARO08-AS |
|---|---|
| Number of hours : 36.00 h | 2.50 ECTS credit |
| CM : 12.00 h, TD : 12.00 h, TP : 12.00 h | handout in English |
| Reference Teacher(s) : GARES VALERIE | |

**Objectives :**
Objectives of this course are to make students acquainted with classical tools for statistical learning and decision-making and with modern techniques for high-dimensional data.

**Content :**
Discriminant analysis Decision trees
Variable selection in high-dimensional settings (penalized methods)
Non-parametric regression using kernel, splines and polynomials-basis functions Model averaging
SVM
Practical with R

**Bibliography :**
T. Hastie, R. Tibshirani, J. Friedman. The elements of statistical learning: data mining, inference, and prediction. Springer, 2009.
S. Tufféry. Data mining et statistique décisionnelle. Technip, 2012.

**Requirements :**
Courses of "Introduction to mathematical softwares", "Linear regression models" (3rd year) and "Risk analysis and scoring" (4th year).

**Organisation :**

**Evaluation :**
One written examination (2/3) and a practical examination and/or project (1/3).

**Target :**

| Nondifferentiable Optimization, Applications in data analysis | ARO08-OND |
|---|---|
| Number of hours : 26.00 h | 2.00 ECTS credit |
| CM : 10.00 h, TP : 16.00 h | handout in English |
| Reference Teacher(s) : HADDOU MOUNIR | |

**Objectives :**
The aim of this course is to give an introduction to non-differentiable convex optimization, to introduce several modern or updated algorithms, recognized for their effectiveness in solving or approaching problems encountered in statistics and data analysis. The course will be partly interactive and half of the practical work will be done in reverse mode.

**Content :**
- nonsmooth analysis and convexity.
- Accelerated gradient and subgradient methods.
- Stochastic and constrained gradient methods.
- Alternated directions methods.
- Nonsmooth optimization techniques.
- Augmented Lagrangien methods and ADMM.
  Labs using MATLAB and CVX.

Applications :
- Sparse inverse covariance estimation.
- Sparse principal components.
- Low-rank decomposition.
- Support Vector Machines.
- Logistic regression, …

**Bibliography :**
S. Boyd et L. Vandenberghe, Convex Optimisation, Cambridge University Press.
S. Boyd et al, CVX : Matlab Software for Disciplined Convex Programming, http://cvxr.com/cvx/
J.F. Bonnans et al. Optimisation numérique. Aspects théoriques et pratiques. Springer, 1997.
J.F. Bonnans. Optimisation continue, Cours et problèmes corrigés. Dunod, 2006.
D. P. Bertsekas Convex Optimization Algorithms ISBN: 1-886529-28-0, 978-1-886529-28-1 , 2015.

**Requirements :**
Courses of “Introduction to mathematical softwares”, ” Continuous optimization” and “numerical Analysis” (3rd year). Basic classical knowledge on statistics.

**Organisation :**

**Evaluation :**
One written examination and a practical examination and/or project .

**Target :**

| Large-Scale Optimization | ARO08-OGD |
|---|---|
| Number of hours : 30.00 h | 2.00 ECTS credit |
| CM : 12.00 h, TD : 8.00 h, TP : 10.00 h | |
| Reference Teacher(s) : BELMILOUDI ABDELAZIZ | |

**Objectives :**
The objective of this course is to introduce methods appropriate to the problems of large-scale complex systems. The main ideas are based on the theory of decomposition-coordination optimization and methods such as interior points. The course will cover practical optimization applications.

**Content :**
Augmented Lagrangian approaches in quadratic optimization
Interior-point methods for solving linear and nonlinear problems
Sequential Quadratic Pragramming (SQP) methods
Decomposition-coordination and proximal decomposition methods
Linear and nonlinear complementarity problems
Optimization problems under equilibrium constraints.
Practice with MATLAB and/or SCILAB softwares

**Bibliography :**
A. Belmiloudi. Stabilization, Optimal and Robust Control. Theory and Applications in Biological and Physical Sciences, Springer-Verlag, 2008
D.P. Bertsekas. Constrained optimization and Lagrange multiplier methods, Academic Press, 1999.
L.T. Biegler et al. (Eds.) Large-Scale Optimization with Applications, Springer-Verlag, 1997.
J.-C. Culioli. Algorithmes de decomposition-coordination en optimisation stochastique. RAIRO, 1986.
M. Grötschel et al. (Eds.) Online Optimization of large Scale Systems, Springer-Verlag, 2001.
B. Jansen. Interior Point Techniques in Optimization ¿ Complementarity, Sensitivity and Algorithms.. Kluwer Academic Publishers. 1997
D.A. Wismer (Ed.), Optimization Methods for Large Scale Systems with Applications, Mac Graw-Hill, 1971.

**Requirements :**
Courses of "Numerical methods of linear", "Numerical methods of nonlinear" of 3rd year and "Optimization" of 4rd year.

**Organisation :**

**Evaluation :**
One written examination and a practical examination and/or project .

**Target :**

| Engineering Practical and Realistic Study | ARO08-BE |
|---|---|
| Number of hours : 36.00 h | 2.50 ECTS credit |
| EP : 36.00 h | |
| Reference Teacher(s) : LE GRUYER YVES | |

**Objectives :**
Our main aim is to offer to an experience of realization of project in relation to industrial partners._This experience will contribute to develop the aptitude of the students to find the relevant mathematical tools and to adapt them to deal with realistic problems. This work is done by group to reinforce the aptitudes of each student to « Team work ».

**Content :**

**Bibliography :**

**Requirements :**

**Organisation :**
The students work is supervised by an industrial partner and a researcher from INSA « Génie Mathématique: Analyse de Risques, Optimisation et Modélisation ».
Each group of students must propose an adapted solution, write a report and defend orally it's work in front of a committee. Several meetings are planned to ensure a complete and effective follow-up.

**Evaluation :**
A mark is awarded by the committee and the industrial advisor after the defense. This mark corresponds to the quality of the work, the report and the oral defense.

**Target :**

| Business Seminar | ARO08-SE |
|---|---|
| Number of hours : 23.00 h | 0.50 ECTS credit |
| CONF : 22.00 h | |
| Reference Teacher(s) : OMER JEREMY | |

**Objectives :**
This module is an open forum for stakeholders of the business world. It covers all semesters of the engineering curriculum and aims at providing the students a broad-spectrum engineering culture. This module will constitute a unique opportunity for students to discover the different career profiles of mathematical engineering. Through this module, the students will also acquire some useful technical, managerial and juridical skills and a solid operational expertise. Finally, this module will help the students raising their awareness to the challenges of sustainable development and to the societal aspects of their future profession of engineer.

**Content :**
In the 4th year, the module will offer (among others) :

• Specific software training ;
• some awareness to specific technical issues related to the profession of mathematical engineer (such as scoring, pricing…).

**Bibliography :**

**Requirements :**

**Organisation :**

**Evaluation :**
The assessment is based on some report delivery.

**Target :**

| Internship | ARO08-STAGE08 |
|---|---|
| Number of hours : 240.00 h | 8.00 ECTS credit |
| ES : 1.00 h | |
| Reference Teacher(s) : LEY OLIVIER | |

**Objectives :**
Each student of the Department Génie Mathématique have to carry out an internship in a company or a research laboratory (in France or in a foreign country). The minimal duration is 8 weeks and an agreement has to be signed between INSA, the company and the student.
This internship takes usually place during the 4th year (in some case during the 3rd year). It can start in May and end before September.
The objectives are to allow the student:
- to get a work experience in an industrial or business environment or/and in research;
- to improve his/her skills in communication, teamwork, creativity, integration in the professional world;
- to have a firsthand opportunity to assess his/her capacities in a job directly related to their field of studies.

**Content :**

**Bibliography :**

**Requirements :**

**Organisation :**
The internship is a full time work in the company under the responsibility of an advisor of the company. The internship is also supervised by a researcher from INSA.

**Evaluation :**
The achievement of the internship provides 8 ECTS credits (which count for the 4th year). The student writes a report leading to an oral defense.
Three marks are given:
- 1 mark awarded by the internship supervisor for work accomplished.
- 1 mark for the written report awarded by the INSA supervisor.
- 1 mark is awarded by a committee (including the INSA supervisor) after the defense.
The average of the marks gives a global mark couting for the 5th year.

**Target :**

| English | HUM08-ANGL |
|---|---|
| Number of hours : 24.00 h | 2.00 ECTS credit |
| TD : 24.00 h, TD : 24.00 h | |
| Reference Teacher(s) : | |

**Objectives :**
Acquiring the required skills for working in a firm as an engineer. Reaching the required level (B2) is compulsory in order to graduate.

**Content :**
-Learning by doing:
The student will have to be able to talk and listen, write documents while showing he/she can solve problems, reason, convince and demonstrate in an articulate manner.
-Expressing oneself accurately and fluently.
The student will engage in activities requiring creative and reactive skills (such as debates, role-plays, individual oral presentations using PowerPoint, projects), which will be based on scientific topics and current events.
-Writing CVs and cover letters
-Scientific English
-Discovering the professional world in an international context
-Preparing for the TOEIC. Furthermore, during the second semester, a specific ¿Toeic Booster¿ course is available for students wishing to attend.

**Bibliography :**
- Oxford Advanced learners¿ Dictionary
- English Grammar in Use (Cambridge University Press)

**Requirements :**
1st, 2nd and 3rd year English courses (or equivalent)

**Organisation :**
Each class lasts two hours and most classrooms are equipped with video and audio. A multimedia language lab and computer rooms are also available and make it possible for the students to work in a stimulating environment. Our teaching resources include press articles, audio and video documents (TV reports, extracts from films and series). We also use the Internet.
Regular personal work is obviously required. The student must be curious and practise English outside the classroom as well.

**Evaluation :**
TOEIC
15 minute oral exam

**Target :**

| Economy and Management | HUM08-ECO |
|---|---|
| Number of hours : 10.00 h | 1.00 ECTS credit |
| TD : 10.00 h, TD : 10.00 h | |
| Reference Teacher(s) : GOURRET FANNY | |

**Objectives :**

**Content :**

**Bibliography :**

**Requirements :**

**Organisation :**

**Evaluation :**

**Target :**

| Engineer & Society - M1 | HUM08-SHES1 |
|---|---|
| Number of hours : 14.00 h | 1.00 ECTS credit |
| TD : 14.00 h, TD : 14.00 h | |
| Reference Teacher(s) : ECHARD PHILIPPE | |

**Objectives :**

**Content :**

**Bibliography :**

**Requirements :**

**Organisation :**

**Evaluation :**

**Target :**

| Engineer & Society - M2 | HUM08-SHES2 |
|---|---|
| Number of hours : 14.00 h | 1.00 ECTS credit |
| CM : 14.00 h, CM : 14.00 h | |
| Reference Teacher(s) : ECHARD PHILIPPE | |

**Objectives :**

**Content :**

**Bibliography :**

**Requirements :**

**Organisation :**

**Evaluation :**

**Target :**

| Sport and Physical Education | HUM08-EPS |
|---|---|
| Number of hours : 20.00 h | 1.00 ECTS credit |
| TD : 20.00 h, TD : 20.00 h | |
| Reference Teacher(s) : | |

**Objectives :**
Team work, discovery of one's capabilities, communication, invention, autonomy, self-discovery and management responsibilities.

**Content :**
Whole class: "role of the coach, role of the referee, management" (knowledge of the rules, getting involved, leading, decision
making and communicating). Practice and knowledge of the sociomotive roles involved in the strategies of team attack and
team defence. Finding one's place in a group and awareness of your team-mates and their responsibilities.
Organisation of Physical and Sports Education: two 15-hour and one 30-hour sports or physical activity programmes in groups.

**Bibliography :**
Specialised publications are available at the library. Internet links are posted and updated on the INSA Physical Education website.

**Requirements :**

**Organisation :**

**Evaluation :**
Evaluation is based upon student participation, progress and acquisition. The student is asked to criticise his own progress with respect to the objectives of the course. The ability to be self-critical leads to self-discovery. Sharing this knowledge with a group reinforces one's confidence.

**Target :**

| Projet de recherche pour la mobilité entrante 24 créduts | DEIF2-MOB24-GM |
|---|---|
| Number of hours : 280.00 h | 24.00 ECTS credit |
| PR : 24.00 h | |
| Reference Teacher(s) : | |

**Objectives :**

**Content :**

**Bibliography :**

**Requirements :**

**Organisation :**

**Evaluation :**

**Target :**

**Semestre 8**

**Parcours Recherche**

| | | | | |
|---|---|---|---|---|
| **1** | **ARO08-INFOS** | | **SCIENTIFIC COMPUTING AND DISCRETE MATHEMATICS** | **7.00** |
| | ARO08-CHP | O | High Performance Computing | 2.00 |
| | ARO08-MERN | O | Modélisation par EDP et Résolution numérique | 3.00 |
| | ARO08-PMAA | O | Advanced mathematical programming and applications | 2.00 |
| **2** | **ARO08-SN** | | **COMPUTATIONAL SCIENCES** | **6.00** |
| | ARO08-PE | O | Design of Experiments | 2.00 |
| | ARO08-AS | O | Statistical Learning | 2.50 |
| | ARO08-OND | O | Nondifferentiable Optimization, Applications in data analysis | 2.00 |
| | ARO08-OGD | O | Large-Scale Optimization | 2.00 |
| **3** | **ARO08-SEMP-2** | | **SEMINAIRE ENTREPRISE ET PROJET** | **3.00** |
| | ARO08-PR2 | O | Research Project | 2.50 |
| | ARO08-SE | O | Business Seminar | 0.50 |
| **4** | **ARO08-STAGE** | | **INTERNSHIP** | **8.00** |
| | ARO08-STAGE08 | O | Internship | 8.00 |
| **5** | **HUM08** | | **Non-scientific syllabus S8** | **6.00** |
| | HUM08-ANGL | O | English | 2.00 |
| | HUM08-ECO | O | Economy and Management | 1.00 |
| | HUM08-SHES1 | O | Engineer & Society - M1 | 1.00 |
| | HUM08-SHES2 | O | Engineer & Society - M2 | 1.00 |
| | HUM08-EPS | O | Sport and Physical Education | 1.00 |

O = compulsary, C= in choice , F= optional

| High Performance Computing | ARO08-CHP |
|---|---|
| Number of hours : 36.00 h | 2.00 ECTS credit |
| CM : 10.00 h, TD : 6.00 h, TP : 20.00 h | |
| Reference Teacher(s) : PAZAT JEAN-LOUIS | |

**Objectives :**
The aim of this course is to provide the basic knowledge about High Performance Tools and programming techniques. We put emphasis both on using standard multicore architectures of desktop machines and on programming large clusters such at Top 500 machines.

**Content :**
Performance, complexity, speed-up
Overview of high performance computer architectures
Parallel Programming
Some models : map Reduce (Hadoop), multithreading (PThreads, OpenMP), introduction to the SIMD model, Message Passing (MPI).

**Bibliography :**
R. Chandra, R. Menon, L. Dagum, D. Kohr, D. Maydan, J. McDonald. Parallel Programming in OpenMP. Morgan Kaufmann, 2000.
T. Rauber, G. Rünger. Parallel Programming: for Multicore and Cluster Systems. 2nd edition 2013.
W. Gropp, E. Lusk, A. Skjellum. Using MPI: Portable Parallel Programming with the Message-Passing Interface. MIT Press, 1999.
W. Gropp, E. Lusk, R. Thakur. Using MPI-2. MIT Press, 1999.

**Requirements :**
Unix basic knowledge, C-programming knowledge.

**Organisation :**

**Evaluation :**
One written examination

**Target :**

| Modélisation par EDP et Résolution numérique | ARO08-MERN |
|---|---|
| Number of hours : 42.00 h | 3.00 ECTS credit |
| | |
| Reference Teacher(s) : | |

**Objectives :**

**Content :**

**Bibliography :**

**Requirements :**

**Organisation :**

**Evaluation :**

**Target :**

| Advanced mathematical programming and applications | ARO08-PMAA |
|---|---|
| Number of hours : 26.00 h | 2.00 ECTS credit |
| CM : 10.00 h, TD : 6.00 h, TP : 10.00 h | handout in English |
| Reference Teacher(s) : ARSLAN AYSE NUR | |

**Objectives :**
This course is a presentation of advanced mathematical programming techniques that are commonly used in the industry and academia to solve challenging problems. The main objectives are:
• To master the most commonly used methods of mathematical programming and understand the challenges behind their efficient implementation and use,
• To understand how these methods are applied to the most well-known and challenging problems encountered in the industry,
• To gain the ability to develop and implement such techniques to newly encountered problems.

**Content :**
• Introduction to dynamic programming,
• Dantzig-Wolfe decomposition and column generation,
• Branch-and-Price algorithm and its efficient implementation,
• Branch-and-Price applications: cutting stock, vehicle routing and bin-packing,
• Benders decomposition and its efficient implementation,
• Benders decomposition applications: facility location, network design,
• Modeling and solution of problems using the modeling language JuMP and the optimization libraries CPLEX, Gurobi, Coin CBC, etc.
• Implementation of solution algorithms using Julia language

**Bibliography :**
[1] Vanderbeck, François, and Laurence A. Wolsey. "Reformulation and decomposition of integer programs." 50 Years of Integer Programming 1958-2008. Springer, Berlin, Heidelberg, 2010. 431-502.
[2] M. Minoux, Programmation mathématique?: théorie et algorithmes, 2e édition. 2008.
[3] G. L. Nemhauser and L. A. Wolsey, “Integer and Combinatorial Optimization,” 1999
[4] L. A. Wolsey, Integer programming. 1998

**Requirements :**
First and second year courses of linear algebra, courses of "Optimization", "Discrete optimization", “Operations Research” and "Numerical Analysis" (3rd year).

**Organisation :**

**Evaluation :**
One exam (50 %), one Julia project (40 %) and one homework (10 %)

**Target :**
Engineering students with a background in applied mathematics.

| Design of Experiments | ARO08-PE |
|---|---|
| Number of hours : 28.00 h | 2.00 ECTS credit |
| CM : 10.00 h, TD : 12.00 h, TP : 6.00 h | handout in English |
| Reference Teacher(s) : CHAGNEAU PIERRETTE | |

**Objectives :**
This course is intended to familiarize students with experimental design methodology. At the end of the course, students will have a knowledge of different possible classes of experimental designs. They should be able to design an experiment and to analyze the obtained results with appropriate statistical methods.

**Content :**
One-way ANOVA, Two-way ANOVA with replication
Introduction to experimental design methodology
Factorial designs
Fractional factorial designs
Response surface designs
Design for mixture experiments

**Bibliography :**
J.-M. Azaïs, J.-M. Bardet. Le modèle linéaire par l'exemple. Dunod, 2005.
J.J. Droesbeke, J. Fine, G. Saporta. Plans d'expériences : Applications à l'entreprise. Editions Technip, 1997.
J. Goupy, L. Creighton. Introduction aux plans d'expériences. Dunod, 3ème édition, 2006.
J. Goupy. Plans d'expériences pour surfaces de réponse. Dunod, 1999.
W. Tinsson. Plans d'expériences : constructions et analyses statistiques. Springer, 2010.

**Requirements :**
Algebra courses from the undergraduate program of INSA (years 1-2) or equivalent skills.
Linear regression models
Introduction to mathematical software

**Organisation :**

**Evaluation :**
One written examination of 2h

**Target :**

| Statistical Learning | ARO08-AS |
|---|---|
| Number of hours : 36.00 h | 2.50 ECTS credit |
| CM : 12.00 h, TD : 12.00 h, TP : 12.00 h | handout in English |
| Reference Teacher(s) : GARES VALERIE | |

**Objectives :**
Objectives of this course are to make students acquainted with classical tools for statistical learning and decision-making and with modern techniques for high-dimensional data.

**Content :**
Discriminant analysis Decision trees
Variable selection in high-dimensional settings (penalized methods)
Non-parametric regression using kernel, splines and polynomials-basis functions Model averaging
SVM
Practical with R

**Bibliography :**
T. Hastie, R. Tibshirani, J. Friedman. The elements of statistical learning: data mining, inference, and prediction. Springer, 2009.
S. Tufféry. Data mining et statistique décisionnelle. Technip, 2012.

**Requirements :**
Courses of "Introduction to mathematical softwares", "Linear regression models" (3rd year) and "Risk analysis and scoring" (4th year).

**Organisation :**

**Evaluation :**
One written examination (2/3) and a practical examination and/or project (1/3).

**Target :**

| Nondifferentiable Optimization, Applications in data analysis | ARO08-OND |
|---|---|
| Number of hours : 26.00 h | 2.00 ECTS credit |
| CM : 10.00 h, TP : 16.00 h | handout in English |
| Reference Teacher(s) : HADDOU MOUNIR | |

**Objectives :**
The aim of this course is to give an introduction to non-differentiable convex optimization, to introduce several modern or updated algorithms, recognized for their effectiveness in solving or approaching problems encountered in statistics and data analysis. The course will be partly interactive and half of the practical work will be done in reverse mode.

**Content :**
- nonsmooth analysis and convexity.
- Accelerated gradient and subgradient methods.
- Stochastic and constrained gradient methods.
- Alternated directions methods.
- Nonsmooth optimization techniques.
- Augmented Lagrangien methods and ADMM.
  Labs using MATLAB and CVX.

Applications :
- Sparse inverse covariance estimation.
- Sparse principal components.
- Low-rank decomposition.
- Support Vector Machines.
- Logistic regression, …

**Bibliography :**
S. Boyd et L. Vandenberghe, Convex Optimisation, Cambridge University Press.
S. Boyd et al, CVX : Matlab Software for Disciplined Convex Programming, http://cvxr.com/cvx/
J.F. Bonnans et al. Optimisation numérique. Aspects théoriques et pratiques. Springer, 1997.
J.F. Bonnans. Optimisation continue, Cours et problèmes corrigés. Dunod, 2006.
D. P. Bertsekas Convex Optimization Algorithms ISBN: 1-886529-28-0, 978-1-886529-28-1 , 2015.

**Requirements :**
Courses of “Introduction to mathematical softwares”, ” Continuous optimization” and “numerical Analysis” (3rd year). Basic classical knowledge on statistics.

**Organisation :**

**Evaluation :**
One written examination and a practical examination and/or project .

**Target :**

| Large-Scale Optimization | ARO08-OGD |
|---|---|
| Number of hours : 30.00 h | 2.00 ECTS credit |
| CM : 12.00 h, TD : 8.00 h, TP : 10.00 h | |
| Reference Teacher(s) : BELMILOUDI ABDELAZIZ | |

**Objectives :**
The objective of this course is to introduce methods appropriate to the problems of large-scale complex systems. The main ideas are based on the theory of decomposition-coordination optimization and methods such as interior points. The course will cover practical optimization applications.

**Content :**
Augmented Lagrangian approaches in quadratic optimization
Interior-point methods for solving linear and nonlinear problems
Sequential Quadratic Pragramming (SQP) methods
Decomposition-coordination and proximal decomposition methods
Linear and nonlinear complementarity problems
Optimization problems under equilibrium constraints.
Practice with MATLAB and/or SCILAB softwares

**Bibliography :**
A. Belmiloudi. Stabilization, Optimal and Robust Control. Theory and Applications in Biological and Physical Sciences, Springer-Verlag, 2008
D.P. Bertsekas. Constrained optimization and Lagrange multiplier methods, Academic Press, 1999.
L.T. Biegler et al. (Eds.) Large-Scale Optimization with Applications, Springer-Verlag, 1997.
J.-C. Culioli. Algorithmes de decomposition-coordination en optimisation stochastique. RAIRO, 1986.
M. Grötschel et al. (Eds.) Online Optimization of large Scale Systems, Springer-Verlag, 2001.
B. Jansen. Interior Point Techniques in Optimization ¿ Complementarity, Sensitivity and Algorithms.. Kluwer Academic Publishers. 1997
D.A. Wismer (Ed.), Optimization Methods for Large Scale Systems with Applications, Mac Graw-Hill, 1971.

**Requirements :**
Courses of "Numerical methods of linear", "Numerical methods of nonlinear" of 3rd year and "Optimization" of 4rd year.

**Organisation :**

**Evaluation :**
One written examination and a practical examination and/or project .

**Target :**

| Research Project | ARO08-PR2 |
|---|---|
| Number of hours : 36.00 h | 2.50 ECTS credit |
| PR : 36.00 h | |
| Reference Teacher(s) : LEDOUX JAMES | |

**Objectives :**
The objective is to propose a discovery of the profession of researcher and its professional environment in an academic or industrial context.

**Content :**
A project exploring one of the themes favored by the student will be proposed by a researcher from an academic/industrial laboratory in Rennes. It is adapted to the skills acquired until then by the student.
It is requested to conduct an interview with a researcher from at least three different laboratories. The project can be accompanied by any initiative of discovery of the world of research (visit of academic or industrial laboratory, participation in meetings of follow-up of research projects, process of publication of a scientific article ...)

**Bibliography :**
Each project is based on a specific bibliographic study.

**Requirements :**
36h are reserved in the timetable of the semester. Each session is an opportunity to discuss with his tutor.

**Organisation :**

**Evaluation :**
A report of not more than 25 pages which can be written in English. A 20 minutes defense in English.

**Target :**
3 students with strong academic results

| Business Seminar | ARO08-SE |
|---|---|
| Number of hours : 23.00 h | 0.50 ECTS credit |
| CONF : 22.00 h | |
| Reference Teacher(s) : OMER JEREMY | |

**Objectives :**
This module is an open forum for stakeholders of the business world. It covers all semesters of the engineering curriculum and aims at providing the students a broad-spectrum engineering culture. This module will constitute a unique opportunity for students to discover the different career profiles of mathematical engineering. Through this module, the students will also acquire some useful technical, managerial and juridical skills and a solid operational expertise. Finally, this module will help the students raising their awareness to the challenges of sustainable development and to the societal aspects of their future profession of engineer.

**Content :**
In the 4th year, the module will offer (among others) :

• Specific software training ;
• some awareness to specific technical issues related to the profession of mathematical engineer (such as scoring, pricing…).

**Bibliography :**

**Requirements :**

**Organisation :**

**Evaluation :**
The assessment is based on some report delivery.

**Target :**

| Internship | ARO08-STAGE08 |
|---|---|
| Number of hours : 240.00 h | 8.00 ECTS credit |
| ES : 1.00 h | |
| Reference Teacher(s) : LEY OLIVIER | |

**Objectives :**
Each student of the Department Génie Mathématique have to carry out an internship in a company or a research laboratory (in France or in a foreign country). The minimal duration is 8 weeks and an agreement has to be signed between INSA, the company and the student.
This internship takes usually place during the 4th year (in some case during the 3rd year). It can start in May and end before September.
The objectives are to allow the student:
- to get a work experience in an industrial or business environment or/and in research;
- to improve his/her skills in communication, teamwork, creativity, integration in the professional world;
- to have a firsthand opportunity to assess his/her capacities in a job directly related to their field of studies.

**Content :**

**Bibliography :**

**Requirements :**

**Organisation :**
The internship is a full time work in the company under the responsibility of an advisor of the company. The internship is also supervised by a researcher from INSA.

**Evaluation :**
The achievement of the internship provides 8 ECTS credits (which count for the 4th year). The student writes a report leading to an oral defense.
Three marks are given:
- 1 mark awarded by the internship supervisor for work accomplished.
- 1 mark for the written report awarded by the INSA supervisor.
- 1 mark is awarded by a committee (including the INSA supervisor) after the defense.
The average of the marks gives a global mark couting for the 5th year.

**Target :**

| English | HUM08-ANGL |
|---|---|
| Number of hours : 24.00 h | 2.00 ECTS credit |
| TD : 24.00 h, TD : 24.00 h | |
| Reference Teacher(s) : | |

**Objectives :**
Acquiring the required skills for working in a firm as an engineer. Reaching the required level (B2) is compulsory in order to graduate.

**Content :**
-Learning by doing:
The student will have to be able to talk and listen, write documents while showing he/she can solve problems, reason, convince and demonstrate in an articulate manner.
-Expressing oneself accurately and fluently.
The student will engage in activities requiring creative and reactive skills (such as debates, role-plays, individual oral presentations using PowerPoint, projects), which will be based on scientific topics and current events.
-Writing CVs and cover letters
-Scientific English
-Discovering the professional world in an international context
-Preparing for the TOEIC. Furthermore, during the second semester, a specific ¿Toeic Booster¿ course is available for students wishing to attend.

**Bibliography :**
- Oxford Advanced learners¿ Dictionary
- English Grammar in Use (Cambridge University Press)

**Requirements :**
1st, 2nd and 3rd year English courses (or equivalent)

**Organisation :**
Each class lasts two hours and most classrooms are equipped with video and audio. A multimedia language lab and computer rooms are also available and make it possible for the students to work in a stimulating environment. Our teaching resources include press articles, audio and video documents (TV reports, extracts from films and series). We also use the Internet.
Regular personal work is obviously required. The student must be curious and practise English outside the classroom as well.

**Evaluation :**
TOEIC
15 minute oral exam

**Target :**

| Economy and Management | HUM08-ECO |
|---|---|
| Number of hours : 10.00 h | 1.00 ECTS credit |
| TD : 10.00 h, TD : 10.00 h | |
| Reference Teacher(s) : GOURRET FANNY | |

**Objectives :**

**Content :**

**Bibliography :**

**Requirements :**

**Organisation :**

**Evaluation :**

**Target :**

| Engineer & Society - M1 | HUM08-SHES1 |
|---|---|
| Number of hours : 14.00 h | 1.00 ECTS credit |
| TD : 14.00 h, TD : 14.00 h | |
| Reference Teacher(s) : ECHARD PHILIPPE | |

**Objectives :**

**Content :**

**Bibliography :**

**Requirements :**

**Organisation :**

**Evaluation :**

**Target :**

| Engineer & Society - M2 | HUM08-SHES2 |
|---|---|
| Number of hours : 14.00 h | 1.00 ECTS credit |
| CM : 14.00 h, CM : 14.00 h | |
| Reference Teacher(s) : ECHARD PHILIPPE | |

**Objectives :**

**Content :**

**Bibliography :**

**Requirements :**

**Organisation :**

**Evaluation :**

**Target :**

| Sport and Physical Education | HUM08-EPS |
|---|---|
| Number of hours : 20.00 h | 1.00 ECTS credit |
| TD : 20.00 h, TD : 20.00 h | |
| Reference Teacher(s) : | |

**Objectives :**
Team work, discovery of one's capabilities, communication, invention, autonomy, self-discovery and management responsibilities.

**Content :**
Whole class: "role of the coach, role of the referee, management" (knowledge of the rules, getting involved, leading, decision
making and communicating). Practice and knowledge of the sociomotive roles involved in the strategies of team attack and
team defence. Finding one's place in a group and awareness of your team-mates and their responsibilities.
Organisation of Physical and Sports Education: two 15-hour and one 30-hour sports or physical activity programmes in groups.

**Bibliography :**
Specialised publications are available at the library. Internet links are posted and updated on the INSA Physical Education website.

**Requirements :**

**Organisation :**

**Evaluation :**
Evaluation is based upon student participation, progress and acquisition. The student is asked to criticise his own progress with respect to the objectives of the course. The ability to be self-critical leads to self-discovery. Sharing this knowledge with a group reinforces one's confidence.

**Target :**

**Semestre 9**

**Parcours Formation initiale Génie Mathématique**

| | | | | |
|---|---|---|---|---|
| **1** | **ARO09-IDS** | | **DATA AND SYSTEMS ENGINEERING** | **13.50** |
| | ARO09-CO | C | Optimal Control | 4.50 |
| | ARO09-PARCI | O | Sparsity in Signal and Image Processing | 4.50 |
| | ARO09-OI | O | Optimization under uncertainty | 4.50 |
| **2** | **ARO09-IR** | | **RISK ENGINEERING** | **13.50** |
| | ARO09-AIS | O | Uncertainty and Sensitivity Analysis in Engineering | 4.50 |
| | ARO09-FMDV | O | Reliability and Survival Analysis | 4.50 |
| | ARO09-SEER | C | Rare Events Estimation and Simulation | 4.50 |
| **3** | **ARO09-SE** | | **SEMINAR** | **2.00** |
| | ARO09-SE | O | Business Seminar | 2.00 |
| **4** | **HUM09** | | **Non-scientific syllabus S9** | **5.50** |
| | HUM09-ANGL-CONV | C | English S9 Conversation | 1.50 |
| | HUM09-ANGL-TOEIC | C | TOEIC 5th year | 1.50 |
| | HUM09-PM-A | C | Economics, Law and Business Studies A (Lean six sigma) | 2.00 |
| | HUM09-PM-B | C | Economics, Law and Business Studies B (Human Resource Management) | 2.00 |
| | HUM09-PM-C | C | Economics, Law and Business Studies C (Human Resources Management) | 2.00 |
| | HUM09-PM-D | C | Economics, Law and Business Studies D (MANAGEMENT - ETHICS - RESPONSIBILITY) | 2.00 |
| | HUM09-PM-E | C | Economics, Law and Business Studies E (International Strategy and Development) | 2.00 |
| | HUM09-PM-F | C | Economics, Law and Business Studies F (sustainable development) | 2.00 |
| | EII09-EVST | C | Evaluation stage | 1.00 |
| | HUM09-PM-G | C | Economics, Law and Business Studies G (serious game) | 2.00 |
| | EII09-HUMT | C | Societal responsibility of business | 1.00 |
| | EII09-EVST | C | Evaluation stage | 1.00 |
| | INF09-DROIT | C | Legal Training for Engineers | 2.00 |
| | SRC09-SPEC | C | Conferences | 1.00 |
| | SRC09-CONF | C | SRC09-CONFERENCES | 1.00 |

O = compulsary, C= in choice , F= optional

| Optimal Control | ARO09-CO |
|---|---|
| Number of hours : 48.00 h | 4.50 ECTS credit |
| CM : 16.00 h, TD : 16.00 h, TP : 16.00 h | |
| Reference Teacher(s) : HADDOU MOUNIR | |

**Objectives :**
Our overall goal is to provide an understanding of the main results in optimal control and how they can be used in various applications. We will introduce and investigate key basic optimal control concepts and extend to some advanced algorithms and techniques. We will focus on both modelization and solution techniques.

**Content :**
Modelling principles of a control problem.
Controllability , observability and Stabilization .
Optimality principles .
HJB equations , LQR control .
Direct and indirect methods .
Practical examples and exercises using MATLAB & / or Scilab and AMPL .

**Bibliography :**
M. Bergounioux. Optimisation et contrôle des systèmes linéaires. Dunod, 2001.
A. Locatelli. Optimal control, an introduction. Birkhauser, 2000.
E. Trélat. Contrôle optimal : théorie et applications. Vuibert, 2005.
T. Weber. Optimal control theory. The MIT press 2011.

**Requirements :**
Course assumes a good working knowledge of linear algebra and differential equations. New material will be covered in depth in the class, but a strong background will be necessary. Course material and homework also assume a good working knowledge of MATLAB and AMPL. (AROM-3A1S, AROM-3A2S, AROM-4A1S and AROM-4A2S).

**Organisation :**

**Evaluation :**
One written examination (2/3) and a practical examination and/or project (1/3).

**Target :**

| Sparsity in Signal and Image Processing | ARO09-PARCI |
|---|---|
| Number of hours : 50.00 h | 4.50 ECTS credit |
| CM : 26.00 h, TD : 12.00 h, TP : 12.00 h | |
| Reference Teacher(s) : HERZET CEDRIC | |

**Objectives :**
This module provides an overview of fundamental concepts and tool relying on sparse representations in signal and image processing. Based on a “geometric” vision of the notion of sparse model, the course will describe the main sparse approximation algorithms, their complexity, and the conditions under which their performance can be guaranteed. The goal is to encompass the role of sparsity in tasks ranging from compression and coding to denoising, source separation, compressive sensing, and more generally linear inverse problems.

**Content :**
Reminder on harmonic analysis and Shannon/Nyquist sampling theorem
General principles of sensing
Examples of inverse problems in signal and image processing
Notions of sparsity and applications
Algorithms for sparse representations
Convex optimization for sparse regularization
Performance guarantees of sparse regularization algorithms
Compressive sensing
Sparse modeling: learning of the decomposition dictionary

**Bibliography :**
M. Elad. Sparse and Redundant Representations. From Theory to Applications in Signal and Image Processing. Springer, 2010.
S Mallat. A Wavelet Tour of Signal Processing (3rd edition). Academic Press, 2009.
S. Foucart & H. Rauhut, A mathematical introduction to compressive sensing. Springer. 2013.

**Requirements :**
« Introduction to mathematical softwares », « Data analysis » (ARO05), « Advanced mathematical tools », « Optimization » (ARO07) and « Statistical learning », « High resolution spectra analysis of signals » (ARO08).

**Organisation :**

**Evaluation :**
project + final exam (oral)

**Target :**

| Optimization under uncertainty | ARO09-OI |
|---|---|
| Number of hours : 48.00 h | 4.50 ECTS credit |
| CM : 16.00 h, TD : 16.00 h, TP : 16.00 h | |
| Reference Teacher(s) : OMER JEREMY | |

**Objectives :**
This course will be the opportunity to strengthen the connections between the teachings of probability and optimization of the GM specialty. Its scope is on the introduction of the fundamental concepts of the optimization under uncertainty. We will first present the different models of uncertainty that can be met and the approaches that can be used to deal with them. The rest of the course will focus on the theoretical properties of stochastic programming (minimization of an expected value) and robust optimization (minimization of a maximum value), and on
the practical methods that can solve such problems. The labs will allow the implementation of some of these methods.

**Content :**
• Models of uncertainties; probability distributions, intervals of values, scenarios, historical data, domain of Bertsimas.
• Introduction of the existing approaches: stochastic programming, robust optimization, probabilistic constraints, stochastic dynamic programing, online optimization
• Classical examples: newspaper salesman problem, warehouse location under uncertainty, etc.
• Robust optimization: solution of simple problems with the uncertainty set of Bertsimas, mathematical programming models
• Stochastic programming: theoretical properties, solution by cutting plane generation and Monte-Carlo methods
• Implementation of solution algorithms with Julia Language

**Bibliography :**
[1] Ben-Tal, A., El Ghaoui, L., & Nemirovski, A. (2009). Robust optimization. Robust Optimization (Princeton).
[2] Birge, J. R., & Louveaux, F. (2011). Introduction to Stochastic Programming. New York, Springer.
[3] Kall, P., & Mayer, J. (2004). Stochastic Linear Programming: Models, Theory, and Computation. Springer.
[4] Shapiro, a., Dentcheva, D., & Ruszczy.ski, A. (2009). Lectures on stochastic programming: modeling and theory. SIAM Series on Optimization.

**Requirements :**
• Third and fourth year courses of optimization: Continuous optimization, Discrete optimization and Operational research
• Second and third year courses of probability, and the third-year course on Markovian models
• Advanced skills in programming with Julia Language

**Organisation :**

**Evaluation :**
Project (50 %), labs (30 %), and homework (20 %)

**Target :**
Fifth-year students of the GM specialty

| Uncertainty and Sensitivity Analysis in Engineering | ARO09-AIS |
|---|---|
| Number of hours : 48.00 h | 4.50 ECTS credit |
| CM : 18.00 h, PR : 30.00 h | |
| Reference Teacher(s) : SUEUR ROMAN | |

**Objectives :**
Upon completion of this program, the student will be able to deal with uncertainty quantification in numerical simulation, with exploratory methods of numerical models and sensitivity analysis.

**Content :**
Categorize the sources of uncertainty
Uncertainty propagation
Overview of the methodology
Modelling sources of uncertainty
Analysis in central tendency
Monte-Carlo methods
OpenTURNS overview
Uncertainty methodology with OpenTURNS
Meta-models
Various families of meta-models
Focus on polynomial chaos
Focus on krigeage
Bayesian interpretation
Sensitivity analysis
Global overview
Screening methods
Local methods
Sobol indices
Applicative project with Python (OpenTURNS module)

**Bibliography :**
R. Faivre, B. Iooss, S. Mahévas, D. Makowski, H. Monod (éditeurs). Analyse de sensibilité et exploration de modèles. Applications aux modèles environnementaux. Editions Quae, 2013.
J.P.C. Kleijnen. Design and analysis of simulation experiments. Springer, 2008.
A. Saltelli, K. Chan, E.M. Scott. Sensitivity analysis. Wiley, 2008.

**Requirements :**
« Introduction to mathematical softwares » et « Python and scientific modules » (ARO05), « Linear regression model » (ARO06), « Modelling with partial differential equations and finite element method » and « Optimization » (ARO07), « Design of experiments » (ARO08).

**Organisation :**

**Evaluation :**
An applicative project

**Target :**

| Reliability and Survival Analysis | ARO09-FMDV |
|---|---|
| Number of hours : 48.00 h | 4.50 ECTS credit |
| CM : 20.00 h, TD : 10.00 h, TP : 18.00 h | |
| Reference Teacher(s) : DUPUY JEAN-FRANCOIS, LEDOUX JAMES | |

**Objectives :**
After this course, students will be able to deal with standard probabilistic tools for reliability and survival analysis and to select the (parametric, semiparametric and nonparametric) statistical models suitable for data.

**Content :**
Probabilistic tools for reliability and survival analysis.
Instantaneous risk or failure rate.
Point processes. Some basics on martingales.
Nonparametric methods
Nelson-Aalen and Kaplan-Meier estimators.
Logrank tests
Semi-parametric models
Proportional hazards models
Fragility models (group data, recurrent events)
Validation tools : goodness of fit tests, residuals, influence
Application to industrial and survival data
Practical work R software, Weibull++ and ALTA
A project on real data based on lectures by industrial experts on reliability prediction and validation methods, on operational reliability

**Bibliography :**
O. Aalen, O. Borgan, H. Gjessing. Survival and event history analysis: a process point of view. Springer, 2008.
J.P. Klein, M.L. Moeschberger. Survival analysis: techniques for censored and truncated data. Springer, 2003.
T. Martinussen, T.H. Scheike. Dynamic regression models for survival data. Springer, 2006.
J. O'Quigley. Proportional hazards regression. Springer, 2008.
V. Ozouf. La boîte à outils de la maîtrise des risques en conception - vers une sûreté de fonctionnement efficiente. AFNOR, 2010
Guide d'aide à l'estimation et à la validation de la fiabilité automobile, SIA, 2016

**Requirements :**
Skills from courses « Initiation to mathematical software » (GM-3A1S), « Markov models » and « Inferential statistics » (GM-3A2S), « Stochastic models of dynamical systems » (GM-4A1S).

**Organisation :**

**Evaluation :**
Two written examinations (50%) and a score based on evaluation of the project (50%).

**Target :**

| Rare Events Estimation and Simulation | ARO09-SEER |
|---|---|
| Number of hours : 48.00 h | 4.50 ECTS credit |
| CM : 26.00 h, TP : 22.00 h | |
| Reference Teacher(s) : FURON TEDDY | |

**Objectives :**
This course introduces rare events estimation and simulation presenting methodologies and applications. Algorithms will be applied on real case studies assessing the reliability of complex systems.

**Content :**
Probabilities
FORM/SORM Methods (First / Second Order Reliability Method)
- Evaluation of the probability of failure and early time failure as a function of the stress demand and the resistive stress capability of a system.
Application to the assessment of the reliability of a system.

Rare Events Simulations
- 3 key algorithms: Monte-Carlo methods, Importance sampling, Importance splitting.
Application to computer security (traitor tracing), insurance (risk of bankruptcy), IT service (queuing), hypotheses testing (probability of false positive).

Statistics
Extreme Value Theory
- Distribution of the maximum, Distribution of excesses and related methods (semi-parametric approach)

Practical exercises with R, Matlab and OpenTurns

**Bibliography :**
J. Beirlant, Y. Goegebeur,J. Segers, J. Teugels. Statistics of Extremes, Theory and applications. Wiley, 2004.
J.A. Bucklew. Introduction to Rare Event Simulation. Springer-Verlag, 2004.
O. Ditlevsen, H.O. Madsen. Structural reliability methods. Department of mechanical engineering technical university of Denmark - Maritime engineering, 2004.
C. Robert, G. Casella. Méthodes de Monte-Carlo avec R. Springer-Verlag, 2011.
G. Rubino et B. Tuffin. Rare Event Simulation using Monte Carlo Methods. Wiley, 2009.

**Requirements :**
This course requires the mastering of the following modules : « Probabilities » and « Python and its scientific modules » (ARO05), « Markov models » (ARO06), « Stochastic models of dynamic systems » (ARO07).

**Organisation :**

**Evaluation :**
Written exam and computer-based test and/or project.

**Target :**

| Business Seminar | ARO09-SE |
|---|---|
| Number of hours : 48.00 h | 2.00 ECTS credit |
| CONF : 48.00 h | |
| Reference Teacher(s) : OMER JEREMY | |

**Objectives :**
This module is an open forum for stakeholders of the business world. It covers all semesters of the engineering curriculum and aims at providing the students a broad-spectrum engineering culture. This module will constitute a unique opportunity for students to discover the different career profiles of mathematical engineering. Through this module, the students will also acquire some useful technical, managerial and juridical skills and a solid operational expertise. Finally, this module will help the students raising their awareness to the challenges of sustainable development and to the societal aspects of their future profession of engineer.

**Content :**
In the 5th year, the module will offer (among others) :

- Specific software training ;
- some awareness to specific technical issues related to the profession of mathematical engineer (such as scoring, pricing…).

**Bibliography :**

**Requirements :**

**Organisation :**

**Evaluation :**
The assessment is based on some report delivery.

**Target :**

| English S9 Conversation | HUM09-ANGL-CONV |
|---|---|
| Number of hours : 10.00 h | 1.50 ECTS credit |
| TD : 10.00 h, TD : 10.00 h | |
| Reference Teacher(s) : LE VOT PHILIPPE | |

**Objectives :**
- Improving communication skills in everyday life situations as well as in a professional or social context.
- Obtaining or reinforcing C1 level, strongly advised/recommended by the CTI. t.

**Content :**
- Learning by doing: students will have to be able to speak and listen, write a document while showing they can solve problems, reason, convince and demonstrate in an articulate manner.
- Expressing oneself accurately and fluently: students will engage in activities requiring creative and reactive skills such as debates, role-plays, individual oral Power Point presentations, projects, based on scientific topics and current events.

**Bibliography :**
1. English Grammar in Use (Cambridge University Press)
2. Dictionnaire Collins Cobuild
3. Polycopié de l' INSA

**Requirements :**
Having taken and passed the TOEIC test during the previous two years (800 required)
or any other B2 certification recognized by the CTI.

**Organisation :**
- Each class lasts one hour and most classrooms are equipped with video and audio. A multimedia lab and computer rooms are also available for the students to work in a stimulating environment.
- Teaching resources include press articles, audio and video documents (TV reports, extracts from films and series) as well as the Internet.

**Evaluation :**
Continuous assessment: The final mark (out of 20) will be based on the attendance rate and the personal implication of the student during the class.

**Target :**

| TOEIC 5th year | HUM09-ANGL-TOEIC |
|---|---|
| Number of hours : 20.00 h | 1.50 ECTS credit |
| TD : 20.00 h, TD : 20.00 h | |
| Reference Teacher(s) : LE VOT PHILIPPE | |

**Objectives :**
- Improving communication skills in everyday life situations as well as in company and business context.
- Obtaining or reinforcing the B2 level requested by the CTI.
- Obtaining 800 score at the final TOEIC test.

**Content :**
Learning by doing : students will have to be able to speak and listen, write a document while showing they can solve problems, reason, convince and demonstrate in an articulate manner.
Expressing oneself accurately and fluently : students will engage in activities requiring creative and reactive skills such as debates, role-plays, individual oral Power Point presentations, projects, based on scientific topics and current events.

**Bibliography :**
- English grammar in Use, Intermediate Edition (CUP)
- Robert and Collins bilingual dictionary or Collins Cobuild

**Requirements :**
Not having already taken and passed the TOEIC test during the previous two years
B1/B2 level advised

**Organisation :**
Each class lasts two hours and most classrooms are equipped with video and audio. A multimedia lab and computer rooms are also available for the students to work in a stimulating environment.
Teaching resources include press articles, audio and video documents (TV reports, extracts from films and series) as well as the Internet. B2 level tests are also taken throughout the course.

**Evaluation :**
Final mark based on :
TOEIC score at final exam + attendance (more than 4 non justified absences result in 0/20 mark).

**Target :**
5th year students who haven't already passed their TOEIC

| Economics, Law and Business Studies A (Lean six sigma) | HUM09-PM-A |
|---|---|
| Number of hours : 34.00 h | 2.00 ECTS credit |
| CM : 30.00 h, CM : 30.00 h, TD : 4.00 h, TD : 4.00 h | |
| Reference Teacher(s) : BOUGUENNEC CHRISTELLE | |

**Objectives :**
This course aims to enable students to develop specific management skills in accordance with their personal objectives and professional motivations. Students chose one option among six.

Main learning outcomes are:
- Establishing a strong, specific vocabulary base
- Understanding the main issues that industrial companies deal with (in a specific management field).
- Understanding the importance of teamwork : making collective decisions and producing the expected work in time

**Content :**
* Lean Six Sigma (28h / in French)
Lean Six Sigma is a methodology that enables firms to make their processes more effective and efficient. It¿s the current industry standard for process improvement designed to reduce waste and enhance output quality.

* Law (8h / in French)
Main principles of the French legal system

**Bibliography :**
Given during the course

**Requirements :**
ECONOMICS AND BUSINESS MANAGEMENT - 1
ECONOMICS AND BUSINESS MANAGEMENT - 2

**Organisation :**
This course is opened to students with different engineering backgrounds. Students work together in small groups and gather the necessary information and advices to set out a final report. Groups also benefit from conferences and tutorial sessions performed by professional speakers.

**Evaluation :**
Continuous assessment (collective work)

**Target :**

| Economics, Law and Business Studies B (Human Resource Management) | HUM09-PM-B |
|---|---|
| Number of hours : 34.00 h | 2.00 ECTS credit |
| CM : 30.00 h, CM : 30.00 h, TD : 4.00 h, TD : 4.00 h | |
| Reference Teacher(s) : BOUGUENNEC CHRISTELLE | |

**Objectives :**
This course aims to enable students to develop specific management skills in accordance with their personal objectives and professional motivations. Students chose one option among six.

Main learning outcomes are:
- Establishing a strong, specific vocabulary base
- Understanding the main issues that industrial companies deal with (in a specific management field)
- Understanding the importance of teamwork: making collective decisions and producing the expected work in time

**Content :**
* Human Resource Management (20h / in French)
    - Main current challenges of Human Resource Management
    - Human Resource Management¿s tools and organization
    - Focus on how team managers deal with Human Resource Management

* Law (8h / in French)
    Main principles of the French legal system

* Social legislation (8h / in French)
    Main principles of French social legislation
    Employment contract

**Bibliography :**
Given during the course

**Requirements :**
ECONOMICS AND BUSINESS MANAGEMENT - 1
ECONOMICS AND BUSINESS MANAGEMENT - 2

**Organisation :**
This course is opened to students with different engineering backgrounds. Students work together in small groups and gather the necessary information and advices to set out a final report. Groups also benefit from conferences and tutorial sessions performed by professional speakers.

**Evaluation :**
Continuous assessment (collective work)

**Target :**

| Economics, Law and Business Studies C (Human Resources Management) | HUM09-PM-C |
|---|---|
| Number of hours : 34.00 h | 2.00 ECTS credit |
| CM : 30.00 h, CM : 30.00 h, TD : 4.00 h, TD : 4.00 h | |
| Reference Teacher(s) : BOUGUENNEC CHRISTELLE | |

**Objectives :**
This course aims to enable students to develop specific management skills in accordance with their personal objectives and professional motivations. Students chose one option among six.

Main learning outcomes are:
- Establishing a strong, specific vocabulary base
- Understanding the main issues that industrial companies deal with (in a specific management field)
- Understanding the importance of teamwork: making collective decisions and producing the expected work in time

**Content :**
* Human Resource Management (20h / in French)
    - Main current challenges of Human Resource Management
    - Human Resource Management¿s tools and organization
    - Focus on how team managers deal with Human Resource Management

* Law (8h / in French)
    Main principles of the French legal system

* Social legislation (8h / in French)
    Main principles of French social legislation
    Employment contract

**Bibliography :**
Given during the course

**Requirements :**
ECONOMICS AND BUSINESS MANAGEMENT - 1
ECONOMICS AND BUSINESS MANAGEMENT - 2

**Organisation :**
This course is opened to students with different engineering backgrounds. Students work together in small groups and gather the necessary information and advices to set out a final report. Groups also benefit from conferences and tutorial sessions performed by professional speakers.

**Evaluation :**
Continuous assessment (collective work)

**Target :**

| Economics, Law and Business Studies D (MANAGEMENT - ETHICS - RESPONSIBILITY) | HUM09-PM-D |
|---|---|
| Number of hours : 34.00 h | 2.00 ECTS credit |
| CM : 30.00 h, CM : 30.00 h, TD : 4.00 h, TD : 4.00 h | |
| Reference Teacher(s) : GOURRET FANNY | |

**Objectives :**
This course aims at enabling students to develop specific management skills in accordance with their personal objectives and professional motivations. Students chose one option among six.

Main learning outcomes are:
- Establishing a strong, specific vocabulary base
- Understanding the main issues that industrial companies deal with (in a specific management field).
- Understanding the importance of teamwork : making collective decisions and producing the expected work in time

**Content :**
The program's main objective is to provide a multidisciplinary approach to the field of innovation, strategy and industrial design. This course will give an overview of the innovative process.
During this program, participants will have the opportunity to explore a business case covering the first stage of a product development project.

**Bibliography :**
Given during the course

**Requirements :**
ECONOMICS AND BUSINESS MANAGEMENT - S7 and S8

**Organisation :**
This course is opened to students with different engineering backgrounds. Students work together in small groups and gather the necessary information and advices to set out a final report. Groups also benefit from conferences and tutorial sessions performed by professional speakers.

**Evaluation :**
Continuous assessment (collective work)

**Target :**

| Economics, Law and Business Studies E (International Strategy and Development) | HUM09-PM-E |
|---|---|
| Number of hours : 34.00 h | 2.00 ECTS credit |
| CM : 30.00 h, CM : 30.00 h, TD : 4.00 h, TD : 4.00 h | |
| Reference Teacher(s) : GOURRET FANNY | |

**Objectives :**
This course aims to enable students to develop specific management skills in accordance with their personal objectives and professional motivations. Students chose one option among six.

Main learning outcomes are:
- Establishing a strong, specific vocabulary base
- Understanding the main issues that industrial companies deal with (in a specific management field).
- Understanding the importance of teamwork : making collective decisions and producing the expected work in time.

**Content :**
This course provides students with the tools necessary to understand and work effectively in today's international economic environment. It explores how innovative firms address new markets and compete outside their national frontiers. The course focuses on strategic choices regarding effective actions in international business.

**Bibliography :**
Given during the course

**Requirements :**
ECONOMICS AND BUSINESS MANAGEMENT - 1
ECONOMICS AND BUSINESS MANAGEMENT - 2

**Organisation :**
This course is opened to students with different engineering backgrounds. Students work together in small groups and gather the necessary information and advice to set out a final report. Groups also benefit from conferences and tutorial sessions performed by professional speakers.

**Evaluation :**
Continuous assessment (collective work)

**Target :**

| Economics, Law and Business Studies F (sustainable development) | HUM09-PM-F |
|---|---|
| Number of hours : 34.00 h | 2.00 ECTS credit |
| CM : 30.00 h, CM : 30.00 h, TD : 4.00 h, TD : 4.00 h | |
| Reference Teacher(s) : BOUGUENNEC CHRISTELLE | |

**Objectives :**
This course aims to enable students to develop specific management skills in accordance with their personal objectives and professional motivations. Students chose one option among six.

Main learning outcomes are:
- Establishing a strong, specific vocabulary base
- Understanding the main issues that industrial companies deal with (in a specific management field).
- Understanding the importance of teamwork : making collective decisions and producing the expected work in time

**Content :**
- Project Management (28 h / in French)
    - Efficient Project Management tools and organization according to PMI (Project Management Institute)
    - Agility
    - SCRUM

- Law (8 h / in French)
    Main principles of the French legal system

**Bibliography :**
Given during the course

**Requirements :**
ECONOMICS AND BUSINESS MANAGEMENT - 1
ECONOMICS AND BUSINESS MANAGEMENT - 2

**Organisation :**
This course is opened to students with different engineering backgrounds. Students work together in small groups and gather the necessary information and advice to set out a final report. Groups also benefit from conferences and tutorial sessions performed by professional speakers.

**Evaluation :**
Continuous assessment (collective work)

**Target :**

| Evaluation stage | EII09-EVST |
|---|---|
| Number of hours : 5.00 h | 1.00 ECTS credit |
| EP : 1.00 h, EP : 1.00 h, TA : 4.00 h, TA : 4.00 h | |
| Reference Teacher(s) : | |

**Objectives :**

**Content :**

**Bibliography :**

**Requirements :**

**Organisation :**

**Evaluation :**

**Target :**

| Economics, Law and Business Studies G (serious game) | HUM09-PM-G |
|---|---|
| Number of hours : 34.00 h | 2.00 ECTS credit |
| CM : 30.00 h, CM : 30.00 h, TD : 4.00 h, TD : 4.00 h | course taught in English |
| Reference Teacher(s) : BOUGUENNEC CHRISTELLE | |

**Objectives :**
This course aims to enable students to develop specific management skills in accordance with their personal objectives and professional motivations. Students chose one option among six.

Main learning outcomes are:
-Establishing a strong, specific vocabulary base
-Understanding the main issues that industrial companies deal with (in a specific management field).
-Understanding the importance of teamwork : making collective decisions and producing the expected work in time

**Content :**
* Business Simulation (serious game) (28h / in English)
The business simulation ¿Global Challenge¿ (a CESIM product) has been designed to improve the understanding and knowledge of the complexity of global business operations in a dynamic, competitive environment. It focuses on strategic management, international management and business policy.
The task for the student teams is to manage a global mobile telecommunications company as its technology and markets evolve. Students will develop and execute strategies for their simulated company operating in the USA, Asia, and Europe.
The simulation is based on an online platform that allows students to play in their own language (many languages available: English, Spanish, Portuguese, Chinese,¿).

* Law (8h / in French)
Main principles of the French legal system

**Bibliography :**
Given during the course

**Requirements :**
ECONOMICS AND BUSINESS MANAGEMENT - 1
ECONOMICS AND BUSINESS MANAGEMENT - 2

**Organisation :**
This course is opened to students with different engineering backgrounds. Students work together in small groups and gather the necessary information and advices to set out a final report. Groups also benefit from conferences and tutorial sessions performed by professional speakers.

**Evaluation :**
Continuous assessment (collective work)

**Target :**

| Societal responsibility of business | EII09-HUMT |
|---|---|
| Number of hours : 20.00 h | 1.00 ECTS credit |
| CM : 20.00 h, CM : 20.00 h | |
| Reference Teacher(s) : BOUGUENNEC CHRISTELLE | |

**Objectives :**

**Content :**

**Bibliography :**

**Requirements :**

**Organisation :**

**Evaluation :**

**Target :**

| Evaluation stage | EII09-EVST |
|---|---|
| Number of hours : 5.00 h | 1.00 ECTS credit |
| EP : 1.00 h, EP : 1.00 h, TA : 4.00 h, TA : 4.00 h | |
| Reference Teacher(s) : | |

**Objectives :**

**Content :**

**Bibliography :**

**Requirements :**

**Organisation :**

**Evaluation :**

**Target :**

| Legal Training for Engineers | INF09-DROIT |
|---|---|
| Number of hours : 20.00 h | 2.00 ECTS credit |
| CM : 20.00 h, CM : 20.00 h | |
| Reference Teacher(s) : | |

**Objectives :**
To give to final-year engineers, whether or not in project manager positions, the key legal concepts for understanding the protection of intellectual creations and software, the contractual mechanisms for producing software content, and the terms of software licenses.

**Content :**
5 independent modules CM1 to CM5

CM1: COMPUTER CREATIONS AND ACTORS

CM 2: GENERIC CONTRACTUAL STRUCTURES AND RESPONSIBILITIES

CM 3: SPECIFIC CONTRACTUAL STRUCTURES

CM 4: SOFTWARE LICENSES (INCLUDING GPL)

CM 5: CREATION AND ADMINISTRATION OF WEB SITES

**Bibliography :**
On the internet : http://www.legalis.net/

Books : Informatique, T_l_coms, Internet - Ed Francis Lefebvre 2012

**Requirements :**
passing the introductory module to general law (8H Lectures)

**Organisation :**
Lectures (7 x 2H)

**Evaluation :**
final exam

**Target :**

| Conferences | SRC09-SPEC |
|---|---|
| Number of hours : 16.00 h | 1.00 ECTS credit |
| CM : 16.00 h, CM : 16.00 h | |
| Reference Teacher(s) : | |

**Objectives :**
Teaching students the fundamentals of Project Management and practice within specific projects.

**Content :**
Project's Organization
Planning, analysis and formalization of individual and team goals.
Methodological tools for project management
Analysis of deviations from the specifications
Risk Management
All the concepts covered in this course will be applied to a specific case study within dedicated projects (SRC09 TCBE
module).

**Bibliography :**

**Requirements :**

**Organisation :**

**Evaluation :**
Oral defense of the project (Implementation of the lecture's concepts)

**Target :**

| SRC09-CONFERENCES | SRC09-CONF |
|---|---|
| Number of hours : 16.00 h | 1.00 ECTS credit |
| CM : 16.00 h, CM : 16.00 h | |
| Reference Teacher(s) : PREVOTET JEAN-CHRISTOPHE | |

**Objectives :**
Industrial or academic experts in various domains present small talks (typically 2h) about technical and scientific issues in their domain. The main idea is to open students to the world of industry and research and make them sensitive to state of the art issues.

**Content :**
The talks may vary depending on the availability of experts

**Bibliography :**

**Requirements :**

**Organisation :**

**Evaluation :**
PASS if every session is attended, FAIL otherwise.

**Target :**
5SRC and 5M&N

**Semestre 10**

**Parcours Formation initiale Génie Mathématique**

| 1 | ARO10-PFE | | FINAL YEAR PROJECT | 30.00 |
|---|---|---|---|---|
| | ARO10-PFE | O | End of Studies Project | 30.00 |

O = compulsary, C= in choice , F= optional

| End of Studies Project | ARO10-PFE |
|---|---|
| Number of hours : 350.00 h | 30.00 ECTS credit |
| ES : 4.00 h, ST : 346.00 h | |
| Reference Teacher(s) : LEY OLIVIER | |

**Objectives :**
The 2nd semester of the 5th year of studies is completely devoted to the End of Studies Project (ESP). The ESP is a work-experience placement to enable the student to acquire practical experience in a professional environment and to apply the theoretical knowledge of his studies at the GM department. It aims to develop his teamwork, communication and observation skills, and to improve his capacity to integrate a business environment. For this reason, it is recommended that the work placement takes place in a private company. The ESP needs an agreement (junior engineer level) between the host and INSA.

**Content :**
- Duration: 16 to 24 weeks.
- Period: from the beginning of February to the end of September.
- Host: Industrial or business company, research laboratory in France or abroad. It is strongly advised that the subject is closely related to the topics of the GM department.
- Administrative formalities: All placements are subject to an agreement between the INSA and the host. For further information, please contact the work placement office of the INSA (service des stages). Before all, the subject of the project has to be accepted by the reference teacher of ESP at GM department.

**Bibliography :**

**Requirements :**

**Organisation :**
The student has to learn to manage some situation in a real professional environment and to meet the needs of the employer or advisor. He has to show autonomy and take initiatives. It is important that his work proves his ability to apply the theoretical knowledge of the department GM.

**Evaluation :**
- A short written mid-term report must be sent to the INSA advisor.
- A written report must be handed in time in upon completion of the placement.
- Oral presentation of the report.

The final mark is obtained from:
- the amount and quality of work according the host manager of the student;
- the quality of the writing report according to the INSA advisor;
- the quality of the defence of the internship in front of an examining board.

**Target :**
Electronics and Computer Science Engineer (A-level +5).