Automotive Engineering for Sustainable Mobility (AESM)

Enseignements de 1ère année

Code UE	Intitulé de l'Unité d'Enseignement	Anglais	DDRS	Innov.	Responsable	Total encadré (hors PEA)	ECTS
AUTOMOTIVE ENGINEERING for SUSTAINABLE MOBILITY (AESM)						**664**	***60***
1ère année AESM - Semestre 1						**347**	***30***
1AE01	Trends in Automotive Transportation and Sustainable Mobility				LE MOYNE L.	**10**	***1***
1AE02	Scientific pre-requisite				JABLOUN M.	**50**	***5***
1AE03	Electrical engineering					**50**	***5***
1AE04	IT: programming				JENNANE R.	**50**	***5***
1AE05	Advanced physics				KOURTA A.	**50**	***5***
1AE06	French culture and language				BOUTONNE G.	**70**	***4***
1EVA1	Evaluation enseignements semestre 1				BECK.K	**2**	***0***
Une UE au choix selon option ECM ou VDIV							
1AE07	Vehicle Dynamics 1				HIGELIN P.	**65**	***5***
1AE08	Internal combustion engines				HIGELIN P.	**65**	***5***
1ère année AESM - Semestre 2						**317**	***30***
2AE01	Acquisition systems and signal processing				RAVIER P.	**50**	***5***
2AE02	Real Time Programming				CANALS R.	**50**	***5***
2AE03	Control and simulation of powertrains				CHARLET A.	**35**	***5***
2AE04	Project				HIGELIN P.	**130**	***10***
2EVA1	Evaluation enseignements semestre 2				BECK.K	**2**	***0***
Une UE au choix selon option ECM ou VDIV							
2AE05	Control and on-board diagnostics applied to internal combustion engines				COLIN G.	**50**	***5***
2AE06	Control and on-board diagnostics applied to vehicle dynamics				COLIN G.	**50**	***5***

Automotive Engineering for Sustainable Mobility **1AE01** **Semester 1**

Trends in Automotive Transportation and sustainable Mobility

Supervisor: Luis LE MOYNE **ECTS : 1**

Skills

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

- Understand transport geo-politics
- Understand the inventory of resources
- Recognize operational actors in the transport sector

Syllabus

- Sustainable mobility
- Environmental incentives
- Well-to-wheels CO2 analysis
- Areas for technology improvements

Grading

Written exam

Learning hours

Lectures	Tutorials	Lab sessions	Free labs	Project
10h00	0h00	0h00	0h00	0h00

In person teaching: 10h00

Taught in English: **SD/SR:** **Innovation:**

Automotive Engineering for Sustainable Mobility **1AE02** **Semester 1**

Scientific pre-requisite

Supervisor: Meryem JABLOUN **ECTS : 5**

Skills

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

- Acquire skills and an understanding of mathematical tools necessary for studying and exploring characteristics of linear systems

Syllabus

Fourier series decomposition

Perform Fourier Series decomposition on continous-time periodic signals and understand Gibbs phenomenon

Linear differential equations

Solve linear differential equations: 1st and 2nd order cases: illustration and application to physical systems

Grading

Written exam

Learning hours

Lectures	Tutorials	Lab sessions	Free labs	Project
28h45	21h15	0h00	1h15	0h00

In person teaching: 50h00

Taught in English: 🏳🏳🏳 **SD/SR:** **Innovation:**

Automotive Engineering for Sustainable Mobility **1AE03** **Semester 1**

Electrical engineering

ECTS : 5

Skills

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

- Understand electrical and magnetism principles occurring in electrical motors divided in two parts: electrical motors and the dedicated converters
- Understand the inner working of continuous and synchronous motors
- Quantify the electrical efficiencies using active power, reactive power, apparent power, distortion power and power factor

Syllabus

- Power: quantifying yields and efficiencies
- Active, reactive, apparent, distortion power, power factor
- Three phased system grid
- Harmonic aspects in power and electromagnetic pollution
- Magnetism applied to electrical motors. Loss reduction in permanent magnet rotors of synchronous machines
- Continuous motors and AC/DC, DC/DC converters integrated power electronics. Step down and the step up chopper structures
- Synchronous motors in servo synchronous machines with Pulse Width Modulator frequency converter
- Four practical sessions illustrate three kinds of motors and transformer needed in industrial processes

Grading

Written exam, Oral exam

Learning hours

Lectures	Tutorials	Lab sessions	Free labs	Project
13h45	10h00	26h15	0h00	0h00

In person teaching: 50h00

Taught in English: 🏳🏳🏳 **SD/SR:** 🌍🌍🌍 **Innovation:** 🖋🖋

Automotive Engineering for Sustainable Mobility **1AE04** **Semester 1**

IT: programming

Supervisor: Rachid JENNANE **ECTS : 5**

Skills

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

- Analyze a problem
- Propose an algorithm
- Develop an object architecture for a given problem
- Use a development environment and a C/C++ compiler

Syllabus

Basics

- Structure of a program in C language
- Basic elements (character, type, constants, variables, blocs, etc.)
- Instructions and Operators
- Conditional structures, iterative structures and connections, etc.
- Pointers and dynamic variables
- Arrays
- Strings
- Functions, passing parameters by value, by reference and by address

Object oriented programming

- Classes
- Member variables and member functions
- Specialized constructors
- Overloaded functions and operators
- Data stream
- Abstract classes
- Generic classes

Grading

Written exam

Learning hours

Lectures	Tutorials	Lab sessions	Free labs	Project
16h15	0h00	33h45	13h45	0h00

In person teaching: 50h00

Taught in English: **SD/SR:** **Innovation:**

Automotive Engineering for Sustainable Mobility **1AE05** **Semester 1**

Advanced physics

Supervisor: Azeddine KOURTA **ECTS : 5**

Skills

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

- Understand the inner working of power electronics
- Understand basic automotive aerodynamics
- Solve 1st and 2nd principle based thermodynamic problems

Syllabus

Power electronics

- Semi-conductor physics
- Power MOS
- IGBT

Automotive aerodynamics

- Basics of aerodynamics
- Specificities of automotive aerodynamics
- Wind tunnel experiments

Thermodynamics

- 1st and 2nd principle of thermodynamics
- Ideal gases
- Basic engine cycles

Grading

Written exam, Report

Learning hours

Lectures	Tutorials	Lab sessions	Free labs	Project
32h30	13h45	3h45	0h00	0h00

In person teaching: 50h00

Taught in English: **SD/SR:** **Innovation:**

Automotive Engineering for Sustainable Mobility **1AE06** **Semester 1**

French culture and language

Supervisor: Geanina BOUTONNE **ECTS : 4**

Skills

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

- Understand spoken french and speak basic sentences
- Read and write basic french
- Hold a basic conversation

Syllabus

- French language sounds
- French grammar
- French conjugation
- Interactive discussions in French

Grading

Written exam, Oral exam

Learning hours

Lectures	Tutorials	Lab sessions	Free labs	Project
0h00	70h00	0h00	0h00	0h00

In person teaching: 70h00

Taught in English: **SD/SR:** **Innovation:**

Automotive Engineering for Sustainable Mobility **1AE07** **Semester 1**

Vehicle Dynamics 1

Supervisor: Pascal HIGELIN **ECTS : 5**

Skills

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

- Understand vocabulary, technology and general issues and goals of vehicle dynamics applied to passenger cars
- Choose and model a tire. Design or choose front and rear axles technologies according to an expected behavior. Design suspension systems and anti roll bars
- Model the behavior of a car using several numerical models, and compare them to real world test measurements
- Conduct experimental measurements on a real axle or a complete vehicle to obtain the variation of the geometrical characteristics length and angles for roll, pumping and pitching

Syllabus

- Generalities: SAE Coordinate System. Definition of specific vocabulary. Motion variables. Basic geometry of an Axle (toe, caster, camber, kingpin etc.) and its effect on drivability
- Tire: Constitution and behavior. Vertical, longitudinal and lateral modelling. Auto- align torque. Pacejka Model and introduction to TM Easy Model
- Axle: Kinematics modelling of various axle using the theory of the mechanism. Suspension steer and roll properties. Analysis of the design effects on the change of characteristic angles and length (toe, camber etc.) as a function of pumping and rolling. Roll Center of an axle
- Vertical behavior and suspension design. Spring and shock absorber design for sprung mass, un-sprung mass control in the case of pitching and pumping behavior
- Transversal Behavior: Ackermann Geometry. Jeantaud's steering system. Bicycle Model. Over steer coefficient, characteristic speed, yaw speed gain. Roll Stiffness of an axle. Roll Flexibility. Lateral Load Transfer. Anti-roll bar design
- Numerical simulations and comparison to real test results using several models (Simulink, Thesis)
- Practical work 1: Experimental measurements and modeling of the kinematics roll effects on camber and steering angle for the H-Frame axle
- Practical Work 2: Experimental measurement of suspension steer, roll effect and pitch effect on the geometrical characteristic angles, for a complete car, in case of pure pumping

Grading

Written exam, Oral exam, Report

Learning hours

Lectures	Tutorials	Lab sessions	Free labs	Project
35h00	22h30	7h30	0h00	0h00

In person teaching: 65h00

Taught in English: **SD/SR:** **Innovation:**

Automotive Engineering for Sustainable Mobility **1AE08** **Semester 1**

Internal combustion engines

Supervisor: Pascal HIGELIN **ECTS : 5**

Skills

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

- Understand the physical and chemical processes occurring during combustion and scavenging in internal combustion engines. Understand the behavior of an engine when changing its settings using modeling
- Be able to build an internal combustion engine model. Be able to optimize the size and settings of an engine performance under efficiency, power, emission constraints using modeling

Syllabus

- Combustion: Thermochemistry and Kinetics applied to combustion. The self-ignition. Premixed flames, flammability limits, flame stability, turbulent combustion. Diffusion flames, biphasic combustion. Internal aerodynamics of an engine. Mixture preparation, requirements of spark ignition and self-ignition, initiation and propagation of combustion (definition of core burning speeds), formation of pollutants. Identification of engine manufacturers needs in terms of fundamentals
- Thermodynamic models: Classification of thermodynamic models: air cycle models, one and two zone models, multizone models. Combustion chamber walls losses models. Limits of validity
- Combustion models: semi-empirical combustion models, application to spark ignition engines. Extension to compression ignition engines. Combustion models for spark ignition engines. Combustion models for compression-ignition engines (spray patterns, combustion models in the premix and diffusion phase)
- Scavenging models: filling/emptying models and acoustic 1D intake/exhaust. Boundary conditions: open tubing, closed, partially open junctions. Consideration of thermal losses and friction to the walls. Filling efficiency curves reconstruction
- Specific Tool: Matlab/Simulink, GTpower, CHEMKIN

Grading

Written exam, Oral exam, Report

Learning hours

Lectures	Tutorials	Lab sessions	Free labs	Project
16h15	41h15	7h30	0h00	0h00

In person teaching: 65h00

Taught in English: 🏳🏳🏳 **SD/SR:** 🌍🌍🌍 **Innovation:** 🖊🖊

Automotive Engineering for Sustainable Mobility **2AE01** **Semester 2**

Acquisition systems and signal processing

Supervisor: Philippe RAVIER **ECTS : 5**

Skills

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

- Mastering Analog to Digital conversion for digital systems
- Mastering the Fourier Transform for spectral analysis of the data
- Selecting and implementing an FIR or IIR filter on a dedicated hardware or software architecture

Syllabus

Signal processing basics

- Analog and digital representation, Shannon theorem
- Time and frequency representation
- Fourier transform
- Noise processing

Digital filtering

- Z transform for digital signals
- Transverse filters
- Recursive filters

Grading

Written exam

Learning hours

Lectures	Tutorials	Lab sessions	Free labs	Project
20h00	20h00	10h00	0h00	0h00

In person teaching: 50h00

Taught in English: 🏳🏳🏳 **SD/SR:** **Innovation:**

Automotive Engineering for Sustainable Mobility **2AE02** **Semester 2**

Real Time Programming

Supervisor: Raphaël CANALS **ECTS : 5**

Skills

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

- Mastering techniques for the implementation of digital systems
- Understanding and implementing hardware and software for real-time systems
- Controling the CAN and FlexRay communication buses

Syllabus

Digital systems

- Number coding and algebra
- Analog-to-digital and digital-to-analog conversions

Electronic components

Microcontrollers: applications in automobile
Microcontrollers: structure and implementation
Architecture of a microcontroller board

Role and place of an OS on a processor board
Architecture of an OS
Calls to OS functions

Automotive communication buses

CAN and FlexRay buses architecture
Communication protocols

Grading

Written exam

Learning hours

Lectures	Tutorials	Lab sessions	Free labs	Project
17h30	10h00	13h45	2h30	8h45

In person teaching: 50h00

Taught in English: 🏳🏳🏳 **SD/SR:** **Innovation:**

Automotive Engineering for Sustainable Mobility **2AE03** **Semester 2**

Control & Simulation of Powertrains

Supervisor: Alain CHARLET **ECTS : 5**

Skills

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

- Understanding why and how hybridization works
- Understanding where energy is lost in a car vs driving conditions
- Being able to build a simple model of a car and its control

Syllabus

Part 1: Control of powertrains

Anti-lock Bracking System (ABS) & Cruise control. This study is performed in simulation with the software Matlab/Simulink

Part 2: Simulation of powertrains

An overview of electric hybrid powertrains is proposed
Then, students work on a simulation platform (Simcenter AMESim by Siemens) where they have to build an energy balance of a conventional vehicle
This study is completed by two practical classes on a rolling test bed where students measure energetic performances of a conventional car vs hybrid car (Toyota Yaris)

Grading

Written exam, Oral exam

Learning hours

Lectures	Tutorials	Lab sessions	Free labs	Project
5h00	22h30	7h30	0h00	0h00

In person teaching: 35h00

Taught in English: **SD/SR:** **Innovation:**

Automotive Engineering for Sustainable Mobility **2AE04** **Semester 2**

Project

Supervisor: Pascal HIGELIN **ECTS : 10**

Skills

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

- Split a complex task into subtasks. Plan and schedule tasks
- Work as a group. Assign tasks to members of the group taking dependencies into account
- Select the more adequate modeling level and simulation tool
- Present work performed in a concise way focusing on the most important aspects
- Build working powertrain and vehicle dynamics models based on experimental data

Syllabus

- Reformulation of project subject
- Split subject objectives into tasks and sub-tasks
- Schedule tasks and assign them to project members
- Report work performed, current state and upcoming tasks every 2 weeks

Grading

Thesis, Oral exam

Learning hours

Lectures	Tutorials	Lab sessions	Free labs	Project
0h00	0h00	0h00	0h00	130h00

In person teaching: 130h00

Taught in English: 🏳🏳🏳 **SD/SR:** **Innovation:**

Automotive Engineering for Sustainable Mobility **2AE05** **Semester 2**

Control and on-board diagnosis applied to ICE

Supervisor: Guillaume COLIN **ECTS : 5**

Skills

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

- Find the good set of parameters for a PID controller on simple systems
- Tune an internal combustion engine control
- Control some simple actuators
- Define, parameterize and implement a simple observer-based diagnosis tool

Syllabus

State of the art of engine control: sensors, actuators

- Gasoline engines
- Diesel engines

Automatic control

- Linear Models (1st order, 2nd order)
- Conventional Linear Control (PID)

Applications to powertrain control : labs

- Experimental engine test benches : tuning and control
- Hardware in the Loop (HIL) & Rapid prototyping for Control: Application on valves

On Board Diagnosis

- Rule based diagnosis
- Observer based diagnosis with numerical simulations on Matlab/Simulink

Grading

Written exam, Oral exam

Learning hours

Lectures	Tutorials	Lab sessions	Free labs	Project
23h45	10h00	16h15	0h00	0h00

In person teaching: 50h00

Taught in English: 🏳🏳🏳 **SD/SR:** 🌍🌍 **Innovation:** 🖊🖊

Automotive Engineering for Sustainable Mobility **2AE06** **Semester 2**

Control and on-board diagnosis applied to vehicle dynamics

Supervisor: Guillaume COLIN **ECTS : 5**

Skills

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

- Find the good set of parameters for a PID controller on simple systems
- Tune a vehicle dynamics control
- Control some simple actuators
- Define, parameterize and implement a simple observer-based diagnosis tool

Syllabus

State of the art

Hardware (sensors, actuators...)
Software

Automatic control

- Linear Models (1st order, 2nd order)
- Conventional Linear Control (PID)

Applications to vehicle dynamics : labs

- Tuning a vehicle dynamics controller
- Hardware in the Loop (HIL) & Rapid prototyping for Control: Application on valves

On Board Diagnosis

- Rule based diagnosis
- Observer based diagnosis with numerical simulations on Matlab/Simulink

Grading

Written exam, Oral exam

Learning hours

Lectures	Tutorials	Lab sessions	Free labs	Project
31h15	8h45	10h00	0h00	0h00

In person teaching: 50h00

Taught in English: **SD/SR:** **Innovation:**