MECA0527
ELECTRIC, HYBRID, and FUEL CELL VEHICLES

Pierre DUYSINX
University of Liege
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Course target

- Understanding, analyzing, and designing clean propulsion systems for vehicles
  - = understanding the environment and energy challenges of transport systems
  - = understanding the problems and constraints of energy conversion systems in vehicle applications (impact upon vehicle architecture and performances)
  - = understanding the different kinds of propulsion systems (thermal engines, electric motors, electrochemical converters, etc.)
  - = understanding the different energy storage systems (fuels, batteries, supercaps, fly wheels, etc.)
  - = understanding how to combine them to take the best of each of them in an integrated system

Course target

- Assess the performance of the propulsion system and of the electric vehicle
- Choose a motor with its fuel / energy
- Combine several solutions (hybrid propulsion systems)
- Devise an optimal energy / power management
- Analyze case studies

Agenda

	Date	Title	Room
01	16/09	Organization – Environmental Challenge – Selection of Powertrain (part 1/2)	B52 TP40
02	23/09	Selection of Powertrain (part 2/2)	
03	30/09	Powertrain architectures and transmission technologies	B52 TP40
04	07/10	Internal Combustion engines and e-motors. Modelling	B52 TP40
05	14/10	Performance : Equation of motion. Tractive forces and Road resistance, Performance criteria. Energy consumption	B52 TP40
06	21/10	EV : Performance, Design, Simulation HOMEWORK 1	B52 TP40
07	28/10	Energy storage systems for EV and HEV: batteries	B52 TP40
**	05/11	FALL BREAK	
08	11/11	ARMISTICE	

Agenda

	Date	Title	Room
08	11/11	Energy storage systems for EV and HEV: batteries	B52 TP40
09	18/11	Power storage systems: supercapacitors, flywheels, and hybrid energy storage	B52 TP40
10	25/11	Hybrid electric vehicles: architecture, components, energy managements strategies	B52 TP40
11	02/12	Introduction to fuel cells and fuel cell vehicles	B52 TP40
12	09/12	Design of series and parallel hybrids	B52 TP40
13	16/12	Industrial seminar: The TOYOTA HYBRID SYSTEM (Raf Schuermans, TME)	B52 TP40
		Or Environmental Assessment of EV and HEV	
**	17/12	WINTER BREAK	
**	23/12	HOMEWORK REPORT SUBMISSION	
**	January	EXAM	

Course. Table of Content

- Introduction: context and challenge of automotive industry
- Selection of a propulsion system
  - Selection and comparison
  - Internal combustion engines
  - Electric vehicles
  - Hybrid powertrains
  - Fuel cell vehicles
- Internal Combustion Engines
  - Engine principles and architecture
  - Engine performances and characteristic curves
  - State-of-the-art and Future trends

Course. Table of Content

- Electric motors
  - Electric motor type
  - DC / AC /SRM
  - Power electronics
  - Modelling

- Powertrain technologies
  - ICE powertrain: clutch, MT and AT, differential
  - EV powertrain:
    - Centralized and decentralized motorization
    - Gear boxes and diffrentials?
  - HEV powertrain architectures
    - Series, Parallel, Complex
    - Power split devices: torque and speed coupling

Course. Table of Content

- Fundamental of vehicle propulsion and braking
  - Longitudinal equilibrium
  - Propulsion forces
  - Road resistances
  - Performance evaluation
    - Max speed, gradeability
    - Acceleration
  - Energy consumption and emissions
    - Driving cycles, estimation procedures, chassis dynamometer

Course. Table of Content

- Design principles of EV
  - Performance evaluation
  - Component selection methodology: battery, electric motor, gear box
  - Energy consumption.
  - Simulation

- Energy and power storage systems
  - Batteries
  - Supercaps
  - Flywheels
  - Hybrid systems (composite systems)

Course. Table of Content

- Hybrid vehicles architecture
  - Concept of hybrid powertrain
  - Main components
  - Energy Management strategies
  - Case studies
- Design principles of HEV
  - Series hybrid
  - Parallel hybrid
- Fuel Cell and Fuel Powered Vehicles
  - Principles
  - Modeling
  - Sizing

MECA0527 - Agenda

- Lectures & Exercises
  - Thursday 16/09 → 16/12: 08:45-12:15
    - Institute of Mechanics B52, room TP40
- Labs
  - Thermodynamic Labs (B49)

LECTURES

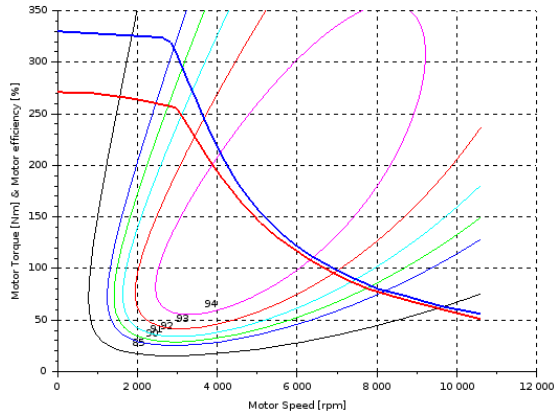
- Green code:
  - Course are given in presence.
  - No constraint
- Yellow code (now)
  - Half of seats are occupied. Min distance 1,0 m. (Preferably 1,5m). Masks are mandatory.
  - Classroom is divided into two groups because no other room is available.
  - Professor do swap after each week (cycles of two weeks)
  - Podcast are recorded during the lectures and posted on MyUliege platform
  - Students are allowed on the campus, but presence must be reduced

LECTURES

- Orange code
  - Max 20% of the students on the campus
  - Course given remotely
  - Podcast are recorded before or delivered using Blackboard Collaborate.
  - Discussion sessions are organized either in small groups or via visio conference systems (LIFESIZE)
- Red code
  - Students are forbidden on the Campus
  - All lectures are recorded and delivered via podcast are recorded during the lectures and posted on MyUliege platform
  - Discussion sessions are organized are only allowed using visio conference systems (LIFESIZE)

Projects and Labs

- Project : Modeling and simulation of an EV
  - Work description (team of 2 students)
    - Data collection
    - Driving scenario
    - Vehicle modelling
    - Performance specification
    - Simulation of energy consumption
    - Effect of transmission selection
      - Single gear ratio, gear box, CVT
    - Comparison and discussion
  - Two homework
    - EV performance
    - Gear box selection and comparison
  - Literature review: read 2 articles



Projects and Labs

- Lab:
  - Chassis dynamometer
  - Group of 4 students
  - Evaluation: Report

Exam et evaluation

- Projects → continuous evaluation
  - Evaluation:
    - Reports:
    - Oral presentation: final discussion and feedback.
- Oral exam
  - Theory (Summary of 4 pages available)
  - Exercise
- Period → January

Lecture notes & Contact

- Copies of slides are available on web site:
  - www.ingveh.ulg.ac.be
    - Cours >> MECA0527
- MyUliege
  - Podcast (if available)
  - Communication

Contact

- Prof. Pierre DUYSINX
  - Email p.duysinx@uliege.be
  - Tel: 04 366.9194
  - Room: 0/514 (B52)

References

- M. Ehsani, Y. Gao, S. Gay, and A. Amadi. Modern Electric, Hybrid Electric, and Fuel Cell Vehicles. Fundamentals, Theory, and Design. CRC Press. 2005.
  - Available at library

- Les véhicules hybrides. Des composants au système. Sous la direction d François Badin. Editions Technip, Paris, 2013
- C.C. Chan and K.T. Chau. « Modern Electric Vehicle Technology » Oxford Science Technology. 2001.
- Advanced Electric Drive Vehicles. Ali Emadi. CRC Press, 2015.
- R. Kaller & J.-M. Allenbach. Traction électrique. Presses Polytechniques et Universitaires Romandes. Vol 1 et 2. 1995.