Welcome to SEC PhD Student Course:

Hybrid Electric Powertrains – Modeling, Control, and Optimization, 4.0 hp

Course credits (suggested):

The course is planned for 4.0 hp for students with engineering background. To have these credits within your PhD curriculum you need an approval of your examiner.

Course goal

After the course the participants have learnt:

- Methods for analyzing energy consumption of vehicles in driving missions.
- The impact of different vehicle design parameters on energy consumption.
- Knowledge of hybrid electric vehicle configurations.
- Component based modeling for system level analysis of energy consumption.
- Knowledge about optimal control and experience from solving the problems with Deterministic Dynamic Programming.
- Experience from developing optimal energy management strategies for Parallel and Series hybrid vehicles.

For whom

The course is aimed for both engineers and researchers working on some aspect of electromobility. It is open for PhD students within the field and employees of the partner companies in the Swedish Electromobility Centre.

The course is not aimed to make the participants experts on vehicle design but introduce them to vehicle system modeling for energy analysis and control optimization.

This course is considered demanding, and it will need commitment from the participants during the time it is running and if you want to pass the course. Hence, it is for those that have time in their schedule and plan for working actively with the assignments during the time the course is running.

Prerequisites

It is necessary to have a Master of Science in engineering, or corresponding experience, and to have a basic understanding of vehicles. The assignments rely on the usage of standard Matlab and Simulink with no extra commercial toolboxes, therefore the participants are encouraged to brush up their knowledge of Matlab and Simulink.

Course structure

The course includes several parts which are mixed during the course:

- An introduction meeting is planned, that describes the course and hand-in assignments.
- Lecturing is done by pre-recorded video lectures of about 60-90 minutes that will be provided at the start of the course.
- At regular intervals, there will be a Q&A session where I will be available in a Zoom-room to answer questions and discuss the contents of the lecture. These Q&A sessions usually last between 15-90 minutes depending on the interest and number of questions.
- There are two hand-in assignments with written reports, these are to be done individually, and handed-in for correction and pass.
- To support you, in the process of solving the assignments, there will be a sequence of Zoom Q&A sessions where you can ask questions about the assignments and get help to develop the solutions.

Project tasks

There are two projects to complete.

- The first one is on implementing an analysis tool for vehicle energy demand in driving missions and using it for analyzing the energy demands for different drive cycles. A final task is to use the tools to dimension the battery so that it fulfills the desired range.
- In the second project two passenger vehicle powertrains (a series and a parallel hybrid) are modelled and dynamic programming is used to find the optimal energy management strategies for the vehicles over different driving missions.

Project work and group

The projects are completed individually at home/office and then there are time slots where you can ask questions and get help and input on your assignments. The teacher organizes the Zoom meeting rooms for Q&A sessions after the lectures and Project, while the groups need to arrange suitable rooms for their own meetings or equipment for online group meetings.

Examination

The course will be graded “pass”, or ”fail”. The grade “pass” requires

- Complete reports, describing the solution for and results from the two hand-in tasks.
- Each participant has to be able to “defend” their solutions of the project tasks.

There will not be any written exam.

Examiner

Lars Eriksson, lars.eriksson@liu.se

Course literature

Video Lectures, with accompanying hand-outs.
A Project PM that describes the tasks for the hand-in assignments.

The course content is based on the book:

“Vehicle Propulsion Systems” by Lino Guzzella and Antonio Sciarretta, 3rd Edition.

The book is not necessary but is generally recommended for engineers who are interested in the area of modeling, analysis and optimal control of energy consumption in vehicles.

Cost

The course is free of charge for PhD students within the SEC PhD student network. Spots will be prioritized for PhD students, however, participants from the partner companies in the Swedish Electromobility Centre which are not PhD students can attend but are subject to a course fee of SEK 4,000 (VAT excl.).

Registration

Register at Swedish Electromobility Centre’s website by **10 January 2027, at the latest.**

Course dates

Start 18th January 2027

End 5th February 2027