



*Welcome to*

## Swedish Electromobility Centre PhD course: **Hybrid Electric Powertrains – Modeling, Control and Optimization, 4.0 hp**

### **Examiner:**

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### **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, 3<sup>rd</sup> 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.

### **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.

### **From 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.

### **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 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 video to the course and hand-in assignments will be available before the course starts.
- Lecturing is done by pre-recorded video lectures of about 60-90 minutes that will be released regularly according to a schedule that is provided at the start of the course.
- Two hours after each lecture video has been released, 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 15-75 minutes depending on the interest and number of questions.
- There are two hand-in assignments with written reports, to be done individually at home, 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.

## 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.

## Cost

The course is free of charge for PhD students within the electro mobility field at a Swedish University and for participants from the partner companies in the Swedish Electromobility Centre.

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.

## Registration

Register at Swedish Electromobility Centre’s website, **at the latest, 15 February 2021.**

## Course schedule

|              |               |
|--------------|---------------|
| <b>Start</b> | 1 March 2021  |
| <b>End</b>   | 26 March 2021 |

| When    | What  | Estimated Time for participants | Where  |
|---------|---|---------------------------------|--|
| Week 7  | Course introduction video available.  | 1 h                             | At your computer                                       |
| Week 9  | Video lectures and introduction to project task 1<br>Working on Project 1<br>Q & A Sessions | 8 h<br>16 h<br>4 h              | At your computer<br>Computer Homework<br>Online - Zoom |
| Week 10 | Video lectures and introduction to project task 2<br>Working on Project 2<br>Q & A Sessions | 8 h<br>16 h<br>6 h              | At your computer<br>Computer Homework<br>Online - Zoom |
| Week 11 | Working on Project 2<br>Q & A Sessions  | 24 h<br>4 h                     | Computer Homework<br>Online - Zoom                     |
| Week 12 | Finishing Projects<br>Closing remarks, reflections and guest lecture.                       | 10 h<br>5 h                     | Computer Homework<br>Online - Zoom                     |
|         | total   | 102 h = 4 hp                    |  |