**Nazwa przedmiotu:**

Theory of Electric Vehicles

**Koordynator przedmiotu:**

Arkadiusz Hajduga, PhD

**Status przedmiotu:**

Fakultatywny dowolnego wyboru

**Poziom kształcenia:**

Studia I stopnia

**Program:**

Electric and Hybrid Vehicles Engineering

**Grupa przedmiotów:**

Obowiązkowe

**Kod przedmiotu:**

348

**Semestr nominalny:**

5 / rok ak. 2022/2023

**Liczba punktów ECTS:**

4

**Liczba godzin pracy studenta związanych z osiągnięciem efektów uczenia się:**

Number of hours worked by the student related to achievements of learning outcomes

1) Number of study direct hours - 50,
 including:
a)hours of lecture -30 hours;
 b) hours of calculus exercises - 15h;
c) consultations hours- 1 hour;
 d) hours of tests controlling knowledge - 4 hours;
 2) Student's own work - 70 hours,
 including:
a) 20 hours - studies based on literature;
b) 10 hours -preparing student for the tests;
c) 18 hours - preparing student for the exercises;
d) 22 hours - reports preparation .
 3) TOTAL -120 hours.

**Liczba punktów ECTS na zajęciach wymagających bezpośredniego udziału nauczycieli akademickich:**

Number of ECTS credits related to the classes requiring direct participation of academic teachers

2 ECTS credits - Number of study direct hours - 50, including:
 a)hours of lecture -30 hours;
b) hours of calculus exercises - 15 hours;
c) consultations hours- 1 hour;
d) hours of tests controlling knowledge - 4 hours.;

**Język prowadzenia zajęć:**

angielski

**Liczba punktów ECTS, którą student uzyskuje w ramach zajęć o charakterze praktycznym:**

2 ECTS credits – 55 hours., including:
1) hours of calculus exercises– 15 .;
c) 18 hours - preparing student for the exercises;
d) 22 hours - preparation of partial raports.

**Formy zajęć i ich wymiar w semestrze:**

|  |  |
| --- | --- |
| Wykład:  | 30h |
| Ćwiczenia:  | 15h |
| Laboratorium:  | 0h |
| Projekt:  | 0h |
| Lekcje komputerowe:  | 0h |

**Wymagania wstępne:**

Basic knowledge of problems of electrical engineering, presented at the lecture Electrical engineering and electronics I and II. Basic knowledge of the topics presented at the lectures: Electric Machines, Electrochemistry, Power electronics and Fuel Cells.

**Limit liczby studentów:**

Brak

**Cel przedmiotu:**

After completing the course the student should have a general theoretical knowledge on:

• Getting to know the basic information about the operations modes of the electric vehicle.
• Specifying the parameters of electric machine and electrochemical battery in relation to vehicle operation conditions: acceleration, constant speed and regenerative braking .
• Basis of regenerative braking as the electric drive operation mode
• Method of driving cycle definition.
• Estimations of vehicle motion resistances.
• Selection of electrochemical battery's capacity.
• Definition of performance criteria for the electric powertrain parameters selection.
• The influence of mechanical ratio of transmission unit on the electric vehicle performance

**Treści kształcenia:**

Definition of electric. Introduction to energy accumulation, energy recuperation and power train efficiency for electric drives.
Electric power trains architectures.
Introduction to electric and hybrid vehicles development history in terms of economic aspects.
Electric machine torque transmission to vehicle’s traction wheels. Description of pneumatic tire principles and parameters; Definition of tires adhesion and its cooperation condition with the road.
Definition and estimation of vehicle motion resistance forces.
Basic components of electric drives:
o power source(electrochemical battery, ultracapacitors, fuel cell),
o transducers: electrical to mechanical energy (Electric Machines with control systems),
o torque transmission elements (mechanical transmissions and other components );
Selection of electric vehicle components parameters:
o power of electric machine,
o electrochemical battery capacity,
o gear ratios selection and quantity,
in terms of the criterion of the highest efficiency and lowest possible vehicle weight.
Regenerative braking properties.
Acceleration and braking process of the vehicle, axis load transfer.
Definition of electric vehicle performance indicators.
Evaluation of electric propulsion system in terms of power train architecture.
Electric vehicle torque-speed characteristic.
Cornering of electric vehicle.
Principles of mechanical and electrical differential.
Methods of energy consumption estimation.

Calculus Exercises
• Estimations of motion resistances.
• Selection of electrochemical battery's capacity.
• Impact of gear ratios on vehicle's autonomy.
• Determination of electric vehicle's dynamic characteristic.
• Research on electric vehicle's braking intensity (estimation of braking efficiency).
• Selection and distribution of propulsion torque in multimotors applications (electric differential).

**Metody oceny:**

There is one mark for lectures and exercises. The lectures are assessed based on the 2 tests. Student is obliged to get positive mark for both of them. For each test it is possible to obtain positive mark for answering for at least 60% of questions. The exercises are assessed based on reports from the blocks of problems defined by the teacher.
The final mark for the subject is calculated based on the 60% weight of mark for the lecture and 40% weight of mark for the exercises.

**Egzamin:**

nie

**Literatura:**

1. Stanisław Arczyński „Mechanika ruchu samochodu”.
2. Antoni Szumanowski „Akumulacja w pojazdach”.
3. Antoni Szumanowski „Fundamentals of Hybrid Drives”.
4. Antoni Szumanowski „Projektowanie dyferencjałów elektromechanicznych elektrycznych pojazdów drogowych”.
5. Gianfranco Pistoia „ Electric and Hybrid vehicles – Power Sources, Models,Sustainability, Infrastructure and the market” Elsevier.
6. Mehrdad Ehsani “ Modern Electric, Hybrid Electric and Fuel Cells vehicles Fundamentals, Theory and design” CRC Press.

**Witryna www przedmiotu:**

Brak

**Uwagi:**

Brak

## Efekty przedmiotowe

### Profil ogólnoakademicki - wiedza

**Efekt 1150-0000-ISP-0348 \_ W\_1:**

Student has theoretical knowledge about the electric drive structures and its principles of operation.

Weryfikacja:

Tests and assessments of student progress on the exercises.

**Powiązane efekty kierunkowe:** K\_W05, K\_W08, K\_W12, K\_W19

**Powiązane efekty obszarowe:** T1A\_W03, T1A\_W07, T1A\_W02, T1A\_W04, T1A\_W07, T1A\_W03, T1A\_W05

**Efekt 1150-00000-ISP-0348 \_ W\_2:**

Student has theoretical knowledge and is able to define criteria and limitations in the selection of electric drive parameters.

Weryfikacja:

Tests and assessments of student progress on the exercises.

**Powiązane efekty kierunkowe:** K\_W05, K\_W08, K\_W12, K\_W17, K\_W19

**Powiązane efekty obszarowe:** T1A\_W03, T1A\_W07, T1A\_W02, T1A\_W04, T1A\_W07, T1A\_W03, T1A\_W03, T1A\_W04, T1A\_W07, T1A\_W05

**Efekt 1150-00000-ISP-0348 \_ W\_3:**

Student has theoretical knowledge and is able to define the criteria for controlling electric machine operated in electric differential.

Weryfikacja:

Tests and assessments of student progress on the exercises.

**Powiązane efekty kierunkowe:** K\_W08, K\_W12, K\_W13

**Powiązane efekty obszarowe:** T1A\_W02, T1A\_W04, T1A\_W07, T1A\_W03, T1A\_W03

**Efekt 1150-00000-ISP-0348 \_ W\_4:**

Student has theoretical knowledge and is able to justify the selection of electric drive parameters including the recuperative braking process.

Weryfikacja:

Tests and assessments of student progress on the exercises.

**Powiązane efekty kierunkowe:** K\_W05, K\_W15, K\_W17, K\_W18

**Powiązane efekty obszarowe:** T1A\_W03, T1A\_W07, T1A\_W03, T1A\_W04, T1A\_W07, T1A\_W03, T1A\_W04, T1A\_W07, T1A\_W03, T1A\_W04, T1A\_W07

**Efekt 1150-00000-ISP-0348 \_ W\_5:**

Student has knowledge and is aware of the electric drive parameters influence of on its efficiency and autonomy range.

Weryfikacja:

Tests and assessments of student progress on the exercises.

**Powiązane efekty kierunkowe:** K\_W09, K\_W12, K\_W13, K\_W16

**Powiązane efekty obszarowe:** T1A\_W06, T1A\_W08, T1A\_W03, T1A\_W03, T1A\_W04, T1A\_W07

### Profil ogólnoakademicki - umiejętności

**Efekt 1150-00000-ISP-0348 \_ U\_1:**

Student knows the methods and can perform the selection of power, gear ratio and electrochemical battery capacity for specified electric drive structure.

Weryfikacja:

Tests, assessments of student progress on the exercises and assessment student’s reports.

**Powiązane efekty kierunkowe:** K\_U09, K\_U16

**Powiązane efekty obszarowe:** T1A\_U09, T1A\_U12, T1A\_U12, T1A\_U16

**Efekt 1150-00000-ISP-0348 \_ U\_2:**

Student can carry out the calculation of tractive force for electric vehicle operated in specified driving cycle.

Weryfikacja:

Tests, assessments of student progress on the exercises and assessment student’s reports.

**Powiązane efekty kierunkowe:** K\_U10, K\_U23

**Powiązane efekty obszarowe:** T1A\_U07, T1A\_U08, T1A\_U09, T1A\_U11

**Efekt 1150-00000-ISP-0348 \_ U\_3:**

Student can determine the conditions of electric machines control for vehicle motion along the curvilinear route and verify it using computer simulations method.

Weryfikacja:

Tests, assessments of student progress on the exercises and assessment student’s reports.

**Powiązane efekty kierunkowe:** K\_U11, K\_U12

**Powiązane efekty obszarowe:** T1A\_U08, T1A\_U09, T1A\_U07, T1A\_U08

**Efekt 1150-00000-ISP-0348 \_ U\_4:**

Student can define the recuperative braking conditions in order to maximize the vehicle kinetic energy recovery.

Weryfikacja:

Tests, assessments of student progress on the exercises and assessment student’s reports.

**Powiązane efekty kierunkowe:** K\_U14, K\_U24

**Powiązane efekty obszarowe:** T1A\_U14, T1A\_U15

### Profil ogólnoakademicki - kompetencje społeczne

**Efekt 1150-00000-ISP-0348 \_ K\_1:**

Student is able to work and collaborate with the other group members during exercises and preparation of final report playing different roles depending on the needs.

Weryfikacja:

Evaluation of the way of tasks carried out by the student during the exercise as well as the final report.

**Powiązane efekty kierunkowe:** K\_K02, K\_K04

**Powiązane efekty obszarowe:** T1A\_K02, T1A\_K03, T1A\_K04