



COURSE DESCRIPTION CARD - SYLLABUS

Course name

ADVANCED ALTERNATIVE PROPULSION SYSTEMS: CASE STUDIES FROM PERSONAL MOBILITY TO MARITIME AND AVIATION TRANSPORT [S5ILGIT>NNAT]

Course

Proposed by Discipline

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Year/Semester

3/5

Level of study

Doctoral School

Course offered in

English

Form of study

full-time

Requirements

elective

Number of hours

Lecture

8

Laboratory classes

0

Other

0

Tutorials

0

Projects/seminars

0

Number of credit points

2,00

Coordinators

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Lecturers

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Prerequisites

Basic knowledge of mechanics, thermodynamics, electrical engineering, and propulsion systems used in transportation. Understanding of the fundamental principles of energy conversion and storage, energy efficiency, and the environmental impact of transportation systems. Ability to analyze technical data and interpret scientific research findings. Proficiency in English sufficient to understand and use scientific and technical literature.

Course objective

The aim of the course is to familiarize doctoral students with advanced alternative propulsion systems used in various modes of transport, ranging from personal mobility and road transportation to maritime and aviation transport. Particular emphasis is placed on the comparative analysis of electric, hybrid, hydrogen-based, and alternative fuel propulsion technologies. The course develops students' ability to critically evaluate energy efficiency, technological limitations, environmental impacts, and future development prospects of alternative propulsion systems through case studies, recent scientific advances, and emerging technological trends.

Course-related learning outcomes

Knowledge (W)

W1. The doctoral student knows and understands the operating principles, design, and technical characteristics of alternative propulsion systems, particularly electric, hybrid, and hydrogen-based propulsion systems used in various modes of transport. (SzD_W01)

W2. The doctoral student is familiar with modern electric vehicle charging infrastructure technologies, energy storage and management systems, and the main development trends in the electrification of road, maritime, and aviation transport. (SzD_W02)

Skills (U)

U1. The doctoral student is able to identify and distinguish different alternative propulsion system configurations, including hybrid propulsion architectures, and recognize electric vehicle charging technologies and infrastructure components. (SzD_U01)

U2. The doctoral student is able to analyze and compare technological solutions applied in road, maritime, and aviation transport, considering their energy efficiency, technical limitations, and environmental impact. (SzD_U02)

Social Competences (K)

K1. The doctoral student is prepared to critically evaluate current scientific achievements and development trends in alternative propulsion systems, as well as their potential applications in various modes of transport. (SzD_K01)

K2. The doctoral student recognizes the importance of scientific knowledge and an interdisciplinary approach in addressing challenges related to electrification, improving energy efficiency, and reducing the environmental impact of transport. (SzD_K03)

Methods for verifying learning outcomes and assessment criteria

Learning outcomes presented above are verified as follows:

The course is assessed through a written test conducted at the end of the semester. The test evaluates students' knowledge and understanding of alternative propulsion technologies, including their ability to identify and distinguish different hybrid propulsion system architectures, recognize electric vehicle charging infrastructure and charging technologies, and analyze the basic operating principles of electric and hybrid propulsion systems.

Additionally, the assessment covers the ability to identify alternative propulsion solutions used in maritime and aviation transport, compare their energy efficiency, and recognize key technological challenges and environmental benefits.

Passing criterion: A minimum score of 50% on the written test is required to pass the course.

Programme content

Introduction to Alternative Propulsion Systems – Classification of alternative propulsion systems, basic technical and energy parameters, global development trends, and challenges related to the decarbonization of transport.

Electric Propulsion in Personal Mobility – Electric propulsion systems in bicycles, scooters, motorcycles, and passenger cars; electric motors, control systems, energy storage technologies, and charging infrastructure.

Hybrid and Plug-in Hybrid Propulsion Systems – Hybrid propulsion architectures, energy management strategies, regenerative braking, energy efficiency, and practical applications.

Hydrogen Propulsion and Fuel Cell Technologies – Fuel cells, hydrogen production, storage and distribution, hydrogen-based propulsion systems, and their technological and infrastructural limitations.

Alternative Fuels and Advanced Combustion Systems – Biofuels, synthetic fuels, ammonia, methanol, and other low-emission energy carriers; their potential applications in modern propulsion systems.

Alternative Propulsion in Maritime Transport – Electrification of vessels, hybrid propulsion systems, the use of hydrogen, methanol, and ammonia in shipping; analysis of selected technological solutions.

Alternative Propulsion in Aviation – Electric and hybrid-electric aircraft propulsion, hydrogen-based propulsion systems, sustainable aviation fuels (SAF), and limitations related to weight, range, and energy density.

Comparative Case Studies and Future Development Trends – Comparison of alternative propulsion systems across different transport applications, considering energy efficiency, life-cycle emissions, costs, technological maturity, and implementation prospects.

Course topics

Lecture 1. Alternative Propulsion Systems in Modern Transport

Overview of electric, hybrid, hydrogen-based, and alternative fuel propulsion technologies. Characteristics of energy sources and storage systems, energy efficiency, technological limitations, and development trends in propulsion systems across different modes of transport.

Lecture 2. Energy Infrastructure and Electric Vehicle Charging Systems

Conductive and wireless charging technologies, charging standards, and infrastructure. Energy management systems, power grid integration, smart charging, and challenges related to charging infrastructure development.

Lecture 3. Hybridization and Electrification of Maritime and Inland Waterway Transport

The role of maritime and inland waterway transport in the global transportation system. Ship designs and types, characteristics of marine propulsion systems. Electrification and hybridization of vessels, alternative fuels, and emission reduction technologies in shipping.

Lecture 4. Modern Aviation Technologies and Aircraft Electrification

Modern aircraft designs and the development of aviation propulsion systems. Electric and hybrid-electric propulsion, hydrogen technologies. Technological challenges and future prospects for aircraft electrification. Electrification of airport ground support equipment and vehicles.

Teaching methods

Lectures supported by multimedia presentations, covering theoretical concepts and practical examples of alternative propulsion systems applied in various modes of transport. The lectures are supplemented by case studies, technical diagrams, scientific research findings, and examples of modern technological solutions. Discussions focus on energy efficiency, technological limitations, and future development prospects of the presented propulsion systems.

Bibliography

BASIC:

Grzywacz W., Burnewicz J., *Ekonomika transportu*, Wydawnictwa Komunikacji i Łączności, Warszawa 1989.

Stopford M., *Maritime Economics*, wyd. 3, Routledge, 2009.

Alderton P. M., *Reeds Sea Transport: Operation and Economics*, Bloomsbury Publishing.

Carlton J. S., *Marine Propellers and Propulsion*, wyd. 4, Elsevier, 2018

Ficoń K., *Logistyka morska. Statki, porty, spedycja*, BEL Studio, Warszawa 2010.

Giernalczyk M., Górski Z., *Siłownie okrętowe. Część I: Podstawy napędu i energetyki okrętowej*,

Uniwersytet Morski w Gdyni, Gdynia 2024.

Giernalczyk M., Górski Z., Siłownie okrętowe. Część II: Instalacje okrętowe, Uniwersytet Morski w Gdyni, Gdynia 2024.

Pluciński M., Polskie porty morskie w zmieniającym się otoczeniu zewnętrznym, CeDeWu, Warszawa 2013.

Więckiewicz W., Budowa i wyposażenie statków towarowych, Wydawnictwo Akademii Morskiej w Gdyni, Gdynia 2009.

Szymanowska B., Dąbrowski J., Klimek H., Innowacyjność portów morskich, Wydawnictwo Uniwersytetu Gdańskiego, Gdańsk 2024, ISBN 978-83-8206-651-7.

Jachimowski R. Ocena funkcjonowania terminali kontenerowych w aspekcie realizowanych procesów transportowo-przeładunkowych Oficyna Wydawnicza Politechniki Warszawskiej (2018)

Więckiewicz W., Budowa kadłubów statków morskich, Wydawnictwo Akademii Morskiej w Gdyni, Gdynia 2008.

ADDITIONAL:

Cieślik W., „Alternatywne napędy jednostek pływających – przegląd”, Biuletyn Techniki Jachtowej, nr 3/2019.

Cieślik W., „Łodzie elektryczne z własną elektrownią? Zastosowanie wodorowych ogniw paliwowych w jachtingu”, Biuletyn Techniki Jachtowej, nr 1/2020

Cieślik W., „Nieograniczony zasięg pływania? Możliwości napędu solarnego w łodziach rekreacyjnych”, Biuletyn Techniki Jachtowej, nr 2/2020, s. 10–15.

Cieślik W., „Napędy elektryczne w jachtingu rekreacyjnym”, Biuletyn Techniki Jachtowej, nr 2/2022.

Cieślik W., Zawartowski J., Antczak W., „Eksploracja i diagnostyka jachtowego napędu elektrycznego. Możliwości badawczo-dydaktyczne stanowiska VETUS E-Line 7500 W”, Biuletyn Techniki Jachtowej, nr 15, 2023.

International Maritime Organization, 2023 IMO Strategy on Reduction of GHG Emissions from Ships,

Electric & Hybrid Marine Technology International Magazine

Breakdown of average student's workload

	Hours	ECTS
Total workload	50	2,00
Classes requiring direct contact with the teacher	8	0,50
Doctoral student's own work (literature studies, preparation for laboratory classes/tutorials, preparation for tests/exam, project preparation)	42	1,50