COURSE DESCRIPTION CARD - SYLLABUS

Course name
Design of mechatronic device drives [S1Mech2>PNUM]

Course

Field of study
Mechatronics

Year/Semester
3/5

Area of study (specialization)
–

Profile of study
general academic

Level of study
first-cycle

Course offered in
Polish

Form of study
full-time

Requirements
compulsory

Number of hours

Lecture
15

Laboratory classes
0

Other
0

Tutorials
15

Projects/seminars
30

Number of credit points

4,00

Coordinators

Tomasz Talaśka

Lecturers

Prerequisites

Knowledge: Familiarity with technical drawing, technical mechanics, introduction to mechatronics, structural materials, mathematics, and physics; design of detachable and non-detachable joints; shaft and axle design; bearing selection; calculations and selection of mechanical transmissions and couplings. Skills: Ability to sketch concepts of machine parts and simple mechanisms, determine fixation and loading methods of components, propose suitable materials for machine parts, calculate detachable and non-detachable joints, apply tolerances and fits in machine construction, design shafts and axles, select bearings, and perform calculations and selection of mechanical transmissions and couplings. Social Competencies: Understanding the necessity of expanding one's competencies and willingness to collaborate within a team.

Course objective

The aim of the course is to familiarize students with the design of mechatronic device drives, the structure of drive systems, the selection of drives with a ball screw, timing belt, rack and pinion, as well as the types and selection of guides.

Course-related learning outcomes

Knowledge:

Understands the structure of drive systems, drives with a ball screw, timing belt, rack and pinion drives, and types of guides.

Skills:
Able to design drives with a ball screw.
Able to design drives with a timing belt.
Able to design belt and roller conveyors.
Able to design drives with a rack and pinion.
Able to select guides.

Social competences:
Understands the need for lifelong learning; able to inspire and organize the learning process for others.
Able to collaborate and work in a team, taking on various roles.
Able to set priorities to achieve a task defined by themselves or others.

Methods for verifying learning outcomes and assessment criteria

Learning outcomes presented above are verified as follows:

Lecture
Final assessment: Written test during the last lecture, consisting of three theoretical questions and two practical tasks. Duration: 90 minutes.
Grading criteria:
• Each theoretical question: up to 2 points
• Each practical task: up to 3 points
• Points awarded with 0.5-point accuracy
• Total points available: 12
Grading scale:
• Below 50% → 2.0
• 50% and above → 3.0
• 60% and above → 3.5
• 70% and above → 4.0
• 80% and above → 4.5
• 90% and above → 5.0
Exercises
Final assessment: Written test during the last class, containing 3 to 5 calculation tasks. Duration: 90 minutes.
Grading criteria:
• Each task has a predefined point value (1 to 2 points)
• Points awarded with 0.25-point accuracy
• Total points available: 5
Grading scale:
• Up to 50% → 2.0
• 51% and above → 3.0
• 61% and above → 3.5
• 71% and above → 4.0
• 81% and above → 4.5
• 91% and above → 5.0
Project
Task: Design a mechatronic device drive (calculations, 3D model, detailed and assembly drawings) based on project data provided by the instructor in the first class. The project is completed individually, with ongoing progress verification.
Grading criteria:
• Final presentation of the project during the last class and submission in paper format
• Final grade components:
o Presentation assessment: 25%
o Technical evaluation of the project: 75%

Programme content

Design of drives with a ball screw, design of drives with a timing belt, design of belt and roller conveyors,

design of drives with a rack and pinion, guides, selection of mechatronic drive components, bearing calculation and selection, shaft design, calculations of gear and belt transmissions, calculations of couplings, brakes, and friction joints.

Course topics

Lectures:
Lecture 1 (2) - Designing Drives with Ball Screws
• Construction of drives with ball screws
• Selection of ball screw and nut
• Calculating the average speed and working load
• Checking the load capacity of the ball screw mechanism
• Bearing of the ball screw
• Stiffness and accuracy of the ball screw mechanism
Lecture 2 (2) - Designing Drives with Timing Belts
• Construction of timing belt drives
• Profiles of timing belts and their properties
• Tensioning belts in a belt transmission system
• Calculating linear drives with timing belts
• Calculating the timing belt transmission
Lecture 3 (2) - Designing Belt and Roller Conveyors
• Construction of belt and roller conveyors
• Tensioning devices in belt conveyors
• Designing drive and idler drums
• Designing support rollers
• Selecting the belt and additional components
• Designing roller conveyors
Lecture 4 (2) - Designing Drives with Rack and Pinion
• Construction of rack and pinion drives
• Overview of commercial solutions
• Calculating the strength of rack and pinion drives
Lecture 5 (2) - Guides
• Rolling and sliding guides
• Curved guides
• Calculating and selecting guides
• Integrated guides with drives
Lecture 6 (2) - Selection of Mechatronic Drive Components
• Selecting commercial mechatronic drive components (motors, gearmotors, transmissions, couplings, bearing supports) using configurators and catalogs
• Construction of frames using aluminum profiles and ready connectors
Lecture 7 (1) - Mounting Control Elements
• Cable routing in mechatronic devices
• Cable carriers
• Mounting sensors in mechatronic devices
• Control cabinets
Lecture 8 (2) - Final Assessment
Exercises:
Exercise 1 (2) - Calculation of Basic Gear Transmission Parameters
• Calculating moments and speeds on individual shafts (task 1)
• Calculating basic dimensions of a spur gear (task 2)
• Selecting the number of teeth in a transmission with a specified axis distance and P-0 correction (task 3)
• Calculating the dimensions of a helical gear (task 4)
Exercise 2 (2) - Calculating the Strength of Gears
• Selecting the gear module based on bending strength and Hertz contact pressures (task 5)
• Calculating the dimensions of a bevel gear (task 6)
Exercise 3 (2) - Shaft Design
• Shaft design methodology
• Calculating reactions in supports
• Calculating bending and torsional moments

• Calculating diameters at characteristic points
• Designing a stepped shaft
• Checking the bending and torsional stiffness of the shaft
• Calculating the critical speed of the shaft (task 7)
Exercise 4 (2) - Bearing Selection and Calculation
• Calculating a transverse plain bearing (task 8)
• Calculating a longitudinal plain bearing (task 9)
• Calculating and selecting a rolling bearing (task 10)
Exercise 5 (2) - Belt Transmission Calculations
• Strength calculations for a flat-belt transmission (task 11)
Exercise 6 (2) - Calculating Friction Couplings and Brakes
• Calculating friction couplings: single-plate, multi-plate, and conical (task 12)
• Calculating a disc brake (task 13)
Exercise 7 (1) - Calculating Friction Joints
• Calculating a connection with expanding and clamping rings (task 14)
• Calculating a clamping connection (task 15)
• Calculating a connection with star washers (task 16)
Exercise 8 (2) - Final Assessment
Projects:
Project 1 (2) - Discussion and Distribution of Project Topics
• Establishing project input data
• Assigning project type (positioning-working system consisting of a motor, gear transmission/belt transmission, ball screw/rack and pinion/timing belt, guides, bearings, etc.)
• Discussing the stages of the project
Project 2 (2) - Reviewing State-of-the-Art for the Device Selection
• Reviewing the current state of technology to choose the device for which the designed drive will be dedicated
Project 3-5 (6) - Performing Analytical Calculations for Various Elements of the Designed Drive System
• Selecting components such as motors, couplings, gears, screws, bearings, guides, etc.
Project 6-8 (6) - Creating a 3D CAD Model of the Device
• Using CAD tools, generators, and modules for FEM and kinematic analysis
Project 9-11 (6) - Creating the Assembly Drawing of the Designed Drive
Project 12-13 (2) - Creating Detailed Drawings of Selected Components/Assemblies to Be Manufactured to Order
Project 14 (2) - Project Consultation
Project 15 (2) - Project Completion

Teaching methods

Lecture:
Lecture with a multimedia presentation, using the case study method - analysis of real-world design problem solutions.
Exercises:
Board exercises supported by multimedia presentations, using the case study method - analysis of real-world design problem solutions.
Project:
Workshop methods for practical design exercises. Project-based methods.

Bibliography

Basic:
1. Zbigniew Osiński, Podstawy Konstrukcji Maszyn, Wydawnictwo Naukowe PWN, 2017.
2. Antoni Skoć, Jakub Pałek, Podstawy Konstrukcji Maszyn, Tom 1, 2, 3, Wydawnictwo Naukowe PWN.
3. Marek Dietrich, Podstawy Konstrukcji Maszyn, Tom 1, 2, 3, Wydawnictwo Naukowe PWN, 2017.

Additional:
1. Jerzy Sobolewski, Przekładnie śrubowe kulowe, Wydawnictwo WNT.

Breakdown of average student's workload

	Hours	ECTS
Total workload	100	4,00
Classes requiring direct contact with the teacher	60	2,50
Student's own work (literature studies, preparation for laboratory classes/ tutorials, preparation for tests/exam, project preparation)	40	1,50