

## SYLLABUS OF A MODULE

Polish name of a module	<b>Metrologia techniczna</b>
English name of a module	<b>Engineering metrology</b>
ISCED classification - code	0710
ISCED classification - Field of study	Engineering & engineering trades
Language of instructions	English
Level of qualification: <i>1 – BSc (EQF 6)</i> <i>2 – MSc (EQF 7)</i> <i>3 – PhD (EQF 8)</i>	1
Number of ECTS credit points	5
Examination: <i>EO – oral exam</i> <i>EW – written exam</i> <i>A - assignment</i>	A
Available in semester: <i>S – spring only</i> <i>A – autumn only</i> <i>Y - both</i>	Y

### Number of hours per semester:

Lecture	Exercises	Laboratory	Seminar	E-learning	Project
30	0	30	0	0	0

## **MODULE DESCRIPTION**

### **MODULE OBJECTIVES**

- O1. To provide knowledge of measuring techniques and methods of engineering quantities
- O2. Ability to conduct experiment

### **PRELIMINARY REQUIREMENTS FOR KNOWLEDGE, SKILLS AND OTHER COMPETENCES**

1. Fundamentals of mathematics, physics, mechanics, statistics, thermodynamics and fluid mechanics
2. Ability of individual work and collaboration in a group
3. Knowledge of the principles of work safety when using machinery and technological equipment.

### **LEARNING OUTCOMES**

- LO 1 – Student knows measuring techniques and methods, their applicability and limitations
- LO 2 – Student is able to prepare experiment and to carry out the measurements
- LO 3 – Student knows the rules of functioning of different types of probes and sensors, machines for roughness and waviness measurements.

## MODULE CONTENT

Type of classes – lecture	Number of hours
<b>Lec 1-2</b> - Introduction to metrology, basic definitions. Measurement, measurement chain, uncertainty, errors. Characteristics of measuring devices.	2
<b>Lec 3</b> - History of measurements. ISO standards. Definition of the system of tolerances and fits of shafts and holes. Measurement errors. Direct and indirect measurements.	1
<b>Lec 4-5</b> - Length and angle standards. Basic measurements instruments - callipers, micrometres and sensors (classic and electronic). Measuring machines. Interferometers. Selection of measuring instruments.	2
<b>Lec 6-7</b> - Measurements of shafts, holes and mixed dimensions. Angle and cone measurements.	2
<b>Lec 8-9</b> - Classic and optical measurements of threads and gears.	2
<b>Lec 10-11</b> - The parameters of roughness and waviness. Methods of contact and optical measuring surface roughness. Stereometric method of measuring surface roughness.	2
<b>Lec 12-13</b> - Optical measuring - theory, technique and methods of measuring.	2
<b>Lec 14-17</b> – Coordinate Measuring Machines. Theory, technique and methods of coordinate measurement.	4
<b>Lec 18-19</b> - Flow rate measurements.	2
<b>Lec 20-21</b> - Requirements to be satisfied by measuring techniques applied to dynamic systems (vibrations, turbulent flows etc.). Requirements to be satisfied by anemometers.	2
<b>Lec 22-24</b> - Hot wire anemometry. Constant Current (CCA) and Constant Temperature (CTA) Anemometers.	3
<b>Lec 25-26</b> - Laser Doppler Anemometry (LDA)	2
<b>Lec 27-28</b> - Particle Image Velocimetry (PIV). Other techniques for flow velocity measurements - Particle Tracking Velocimetry (PTV).	2
<b>Lec 29-30</b> - Measurements of loads in flows. Techniques for shear stress measurements. Measurements of flow pollutants concentration, aspirating probes. Electrical Resistance Tomography (ERT)	2
<b>Sum</b>	<b>30</b>
Type of classes– laboratory	Number of hours
<b>Lab 1-4</b> - Measurements of shafts, holes and mixed dimensions with micrometre, calliper and workshop microscope	4
<b>Lab 5-6</b> - Indirect measurements using gauge plates (Johansson blocks) and sensors	2
<b>Lab 7-8</b> - Measurements of threads on a microscope using rollers and gauges.	2
<b>Lab 9-13</b> - Geometry measurements on a 3D CMM ZEISS ECLIPSE coordinate measuring machine. Zeiss Calypso software.	5
<b>Lab 14-15</b> - Surface roughness measurements on 3D Taylor Hobson NTFS 60 profilometer. Circularity measurements on 3D Talyrond 365.	2
<b>Lab 16-19</b> - Determination of a discharge coefficient of an orifice	4
<b>Lab 20-23</b> - Application of hot-wire anemometer (CCA) to measure temperature field in nonisothermal flow.	4
<b>Lab 24-27</b> - Measurement of velocity distribution in turbulent flow by means of CTA system.	4
<b>Lab 28-30</b> - Diagnostics of the flow field with the use of optical techniques - LDA and	3

PIV	
	<b>Sum 30</b>

## TEACHING TOOLS

1. Lecture with the use of multimedia presentations
2. Experimental stands equipped with measuring instrumentation
3. Instructions to laboratory exercises
4. Coordinate Measuring Machine, universal form testers for the analysis of roughness, cylindricity

## WAYS OF ASSESSMENT (F – FORMATIVE, S – SUMMATIVE)

<b>F1</b> - assessment of preparation for laboratory exercises
<b>F2</b> - assessment of the ability to apply the acquired knowledge while doing the exercises
<b>F3</b> - evaluation of reports on the implementation of exercises covered by the curriculum
<b>F4</b> - assessment of activity during classes
<b>S1</b> - assessment of the ability to solve the problems posed and the manner of presentation obtained results - pass mark *
<b>S2</b> - assessment of mastery of the teaching material being the subject of the lecture - exam

\*) in order to receive a credit for the module, the student is obliged to attain a passing grade in all laboratory classes as well as in achievement tests.

## STUDENT'S WORKLOAD

No	Form of activity	Average number of hours required for realization of activity
<b>1. Contact hours with teacher</b>		
1.1	Lectures	30
1.2	Tutorials	0
1.3	Laboratory	30
1.4	Seminar	0
1.5	Project	0
1.6	Examination	0
Total number of contact hours with teacher:		60
<b>2. Student's individual work</b>		
2.1	Preparation for tutorials and tests	15
2.2	Preparation for laboratory exercises, writing reports on laboratories	30
2.3	Preparation of project	0
2.4	Preparation for final lecture assessment	10
2.5	Preparation for examination	0
2.6	Individual study of literature	10
Total number of hours of student's individual work:		65
Overall student's workload:		125 ECTS
<b>Overall number of ECTS credits for the module</b>		<b>5 ECTS</b>

Number of ECTS points that student receives in classes requiring teacher's supervision:	2.4 ECTS
Number of ECTS credits acquired during practical classes including laboratory exercises and projects	2.4 ECTS

## BASIC AND SUPPLEMENTARY RESOURCE MATERIALS

1. Bosch J.A.: Coordinate Measuring Machines and Systems. Marcel Dekker, Inc. New York, Basel, Hong Kong 1995
2. Bucher J. L.: The Metrology Handbook. Quality Press, 2nd edition, 2012
3. Drake P.: Dimensioning and Tolerancing Handbook. McGraw-Hill, New York, 1999.
4. Durst F.: Fluid Mechanics. An introduction to the theory of fluid flows. Springer-Verlag, Berlin, 2008
5. Elsner J.W., Drobnik S.: Metrologia turbulencji przepływów. Ossolineum, Wrocław, 1995
6. Goldstein R.J.: Fluid mechanics measurements. Taylor & Francis, 1996
7. Henzold G.: Handbook of Geometrical Tolerancing. Design, Manufacturing and Inspection. John Willey & Sons, Chichester 1995
8. Hocken R. J., Paulo H. Pereira P. H.: Coordinate Measuring Machines and Systems. CRC Press, 2012
9. Leach R.: Optical Measurement of Surface Topography. Springer; 2011
10. Meadows J.D.: Geometric Dimensioning and Tolerancing: Applications and Techniques for Use In Design, Manufacturing and Inspection. Marcel Dekker, Inc. New York 1995.
11. Whitehouse D.J.: Handbook of surface metrology. Institute of Physics. Bristol 1994
12. Whitehouse D.J.: Surfaces and their Measurement. Kogan Page Science, 2004
13. Yoshizawa T.: Handbook of Optical Metrology: Principles and Applications, CRC Press, 2015

## MODULE COORDINATOR (NAME, SURNAME, E-MAIL ADDRESS)

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