SYLLABUS OF A MODULE

Polish name of a module	**Metrologia techniczna**
English name of a module	**Engineering metrology**
ISCED classification - code	0710
ISCED classification - Field of study	Engineering & engineering trades
Language of instructions	English
Level of qualification:	*1 – BSc (EQF 6)*
Number of ECTS credit points	*5*
Examination:	*A - assignment*
Available in semester:	*S – spring only*

Number of hours per semester:

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

Lab 22-25 - Measurement of velocity distribution in turbulent flow by means of CTA system.	**4**
Lab 26-28 - Flow velocity measurements using LDA	**3**
Lab 29-30 - Flow visualization with the use of PIV	**2**
Sum	**30**

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)

F1 - assessment of preparation for laboratory exercises
F2 - assessment of the ability to apply the acquired knowledge while doing the exercises
F3 - evaluation of reports on the implementation of exercises covered by the curriculum
F4 - assessment of activity during classes
S1 - assessment of the ability to solve the problems posed and the manner of presentation obtained results - pass mark *
S2 - 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
1.	**Contact hours with teacher**	
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
2.	**Student's individual work**	
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
Overall number of ECTS credits for the module	5 ECTS
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. Drake P.: Dimensioning and Tolerancing Handbook. McGraw-Hill, New York, 1999
5. Durst F.: Fluid Mechanics. An introduction to the theory of fluid flows. Springer-Verlag, Berlin, 2008
6. Elsner J.W., Drobniak S.: Metrologia turbulencji przepływów. Ossolineum, Wrocław, 1995
7. Goldstein R.J.: Fluid mechanics measurements. Taylor & Francis, 1996
8. Henzold G.: Handbook of Geometrical Tolerancing. Design, Manufacturing and Inspection. John Willey & Sons, Chichester 1995
9. Hocken R. J., Paulo H. Pereira P. H.: Coordinate Measuring Machines and Systems. CRC Press, 2012
10. Leach R.: Optical Measurement of Surface Topography. Springer; 2011
11. Meadows J.D.: Geometric Dimensioning and Tolerancing: Applications and Techniques for Use In Design, Manufacturing and Inspection. Marcel Dekker, Inc. New York 1995.
12. Whitehouse D.J.: Handbook of surface metrology. Institute of Physics. Bristol 1994
13. Whitehouse D.J.: Surfaces and their Measurement. Kogan Page Science, 2004
14. Yoshizawa T.: Handbook of Optical Metrology: Principles and Applications, CRC Press, 2015

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

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