module title: **METROLOGY & QUALITY ENGINEERING**		
field of study: **Mechanical Engineering**	type of study: **full-time**	course code: **S6_3-9**
course: **Modelling & Simulation in Mechanics**	degree: **Master (MSc)**	year: **I** semester: **I**
type of classes: **lecture, project, laboratory**	hours per week: **4L, 2P, 2Lab**	No of ECTS credits: **7**

MODULE DESCRIPTION

TARGETS

- **T1.** To familiarize students with the basic concepts, principles, selected methods and tools of quality management.
- **T2.** To let students acquire practical skills in quality management.
- **T3.** To make students understand the basic principles of Total Quality Management and to make them freely use the terminology of TQM.
- **T4.** To familiarise students with modern Quality Management issues regarding the team work project work, brainstorm techniques.
- **T5.** To provide the knowledge of measuring techniques applied for fluid flow diagnostics.
- **T6.** To familiarise students with measurements of flow characteristics.

PREREQUISITES & ADDITIONAL REQUIREMENTS

- **R1.** Fundamentals of physics, mechanics, thermodynamics and fluid mechanics.
- **R2.** Basic knowledge of statistics and error estimation.
- **R3.** Safety rules during the use of laboratory equipment.
- **R4.** Capability of using source literature.
- **R5.** Capability of individual work and collaboration in a group.
- **R6.** Data analysis and presentation of results.
- **R7.** Basic knowledge of organization and management.
- **R8.** Basic knowledge of technological processes.

LEARNING OUTCOMES

- **LO1.** Knowledge of the basic principles, methods and tools used in quality management as well as the trends of their development.
- **LO2.** Ability to communicate and work effectively with the use of modern information technology.
- **LO3.** Ability to assess the suitability of each method and quality management tools to solve simple problems related to the improvement of processes.
- **LO4.** Ability to work in a group, taking different roles.
- **LO5.** Knowledge on flow metrology techniques, their capabilities and limitations.
- **LO6.** Ability to choose the measuring technique being the most adequate to the flow configuration and the measurement targets.
- **LO7.** Ability to prepare experiment, set-up the test rig and measuring equipment.
- **LO8.** Ability to analyse, interpret and present the measurement results.

TEACHERS

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- dr Tomasz Walasek - tomek@itm.pcz.pl

MODULE CONTENT

LECTURE	hours
L1-2 - Quality - philosophy, basic concepts and definitions - the past and the present.	**2**
L3-4 - The concepts of quality by recognized experts - Deming.	**2**
L5-6 - The concepts of quality by recognized experts - Juran, Crosby, Conway.	**2**
L7-8 - Total Quality Management - definitions.	**2**
L9-10 - Key aspects of quality management.	**2**
L11-12 - Quality costs - a case study: Challenger space shuttle disaster.	**2**
L13-14 - Quality costs - breakdown of costs.	**2**
L15-16 - ISO 9000 - the genesis of creation, amendments.	**2**
L17-18 - ISO 9000 - quality management principles, process management, structure of standards..	**2**
L19-20 - Integrated Quality, Environmental and Safety Management System, Sustainable Production.	**2**
L21-22 - Documentation of Quality Management System - introduction.	**2**
L23-24 - Documentation of Quality Management System - Quality Policy, Quality Targets, The Book of Quality.	**2**
L25-26 - Documentation of QMS - Procedures, Instructions and Records.	**2**
L27-28 - The development of Quality Management Methods – the benefits of the system.	**2**
L29-30 - Entrepreneurship and start-up.	2
L31-32 - Introduction to metrology, basic definitions. Measurement, measurement chain, uncertainty, errors. Characteristics of measuring devices.	**2**
L33-34 - Requirements to be satisfied by measuring techniques applied to turbulent flows, requirements to be satisfied by anemometers.	**2**
L 35-40 - Fundamentals of hot-wire anemometry (HWA), modes of HWA operation, constant temperature (CTA) and constant current (CCA) anemometers. Directional sensitivity. Measurements of velocity correlations. HWA probes. Pulse anemometer, oscillating anemometer.	**6**
L 41-44 - Laser Doppler anemometry (LDA), physical principle, LDA configurations. Doppler signal analysers. "Velocity bias", processing of randomly sampled time series. Multi-channel LDA systems.	**4**
L 45-47 - Particle Image Velocimetry (PIV). Other techniques for flow velocity measurements - Particle Tracking Velocimetry (PTV), Ultrasonic Doppler Velocimetry (UDV), Optical Coherence Tomography (OCT).	**3**
L 48-49 - Measurements of dispersed phase size. Particle Dynamics Analyser (PDA).	**2**
L 50-54 - Nonintrusive techniques for reacting flows diagnosis. Measurements of chemical composition, radical concentration. Laser Induced Fluorescence (LIF), Laser-Induced Incandescence (LII). Measurements of fluid temperature, Coherent Anti-Stokes Raman Spectroscopy (CARS), Reactive Mie Scattering (RMS).	**5**
L 55-58 - Flow visualisation techniques. Schlieren, smoke visualisation, oil visualisation. Hologram interferometry. Electrical Resistance Tomography (ERT) , Electrical Impedance Tomography (EIT), Magnetic Resonance Imaging (MRI).	**4**
L 59-60 - Measurements of loads in flows. Techniques for shear stress measurements. Measurements of flow pollutants concentration, aspirating probes.	**2**

PROJECT	hours
P 1 - Basic Seven Tools - Flow chart.	**1**
P 2 - Basic Seven Tools - Cause-and-effect diagram (also known as the "fishbone" or Ishikawa diagram).	**1**
P 3 - Basic Seven Tools - Scatter diagram.	**1**
P 4 - Basic Seven Tools - Pareto chart.	**1**
P 5 - Basic Seven Tools - Histogram, Check sheet.	**1**
P 6-7 - Mind Storm as a quality improvement tool.	**2**
P 8 - Seven Management and Planning Tools - Affinity Diagram (KJ Method), Interrelationship Digraph (ID), Tree Diagram.	**1**
P 9 - Seven Management and Planning Tools - Process Decision Program Chart (PDPC), Activity Network Diagram.	**1**
P 10 - Seven Management and Planning Tools - Matrix diagram, Prioritization Matrix.	**1**
P 11-12 - Failure mode and effects analysis FMEA.	**2**
P 13-14 - Quality Function Deployment QFD.	**2**
P 15-16 - Process Capability.	**2**
P 17-18 - New Management Methods - 5S.	**2**
P 19-24 - Lean Manufacturing.	**6**
P 25-26 - Kaizen.	**2**
P 27-29 - Theory of Constrains.	**3**
P 30 - Summary.	**1**

LABORATORY	hours
Lab 1-2 - Elaboration of measurements data. Errors and uncertainty. Measurement accuracy.	**2**
Lab 3-4 - Flow rate measurements by means of an orifice.	**2**
Lab 5-6 - Application of a constant current anemometer (CCA) to measure temperature field in nonisothermal flow.	**2**
Lab 7-10 - Application of constant temperature anemometer (CTA) to measure the velocity field in turbulent flow.	**4**
Lab 11-12 - Correlation and spectral analysis in flow diagnostics.	**2**
Lab 13-14 - Measurements of velocity correlations.	**2**
Lab 15-18 - Velocity measurements in flame with the use of LDA.	**4**
Lab 19-22 - Application of smoke and oil visualisation to identify the flow structure.	**4**
Lab 23-26 - Measurements of micro- and macroscales in turbulent flow.	**4**
Lab 27-30 - Measurements of turbulent kinetic energy dissipation.	**4**

TEACHING TOOLS

1.	Lecture with the use of multimedia presentations and online tools
2.	Project based assignments - online
3.	Discussion, critical thinking
4.	Group work Instructions to laboratory exercises
5.	Project based work
6.	Instructions to project based assignments
7.	Simulations, games
8.	Set of blocks and instructions for a game
9.	Experimental stands equipped with measuring instrumentation
10.	Software
11.	Instructions to laboratory exercises

SOURCE LITERATURE

1.	Womack J.P., Jones D.T.: Lean Thinking, Second Edition, ProdPublishing.com, ISBN 978-83-62776-03-0
2.	Womack J.P., Jones D.T., Roos D.: The Machine That Changed the World: The Story of Lean Production--Toyota's Secret Weapon in the Global Car Wars That Is Now Revolutionizing World Industry, Free Press, ISBN-13: 978-0743299794
3.	ISO 9001:2008 "Quality management systems - Requirements"
4.	ISO 9000:2005 "Quality management systems. Fundamentals and vocabulary"
5.	ISO 9004:2009 "Managing for the sustained success of an organization. A quality management approach"
6.	Bank J.: Essence of Total Quality Management, Prentice Hall, ISBN-13: 978-0132849029
7.	Goldratt E.M., Cox J.: The Goal, North River Press, ISBN 0-88427-061-0
8.	Goldratt E.M.: Critical Chain, ISBN 0-88427-153-6
9.	Goldstein R.J.: Fluid mechanics measurements. Taylor & Francis, 1996
10.	Durst F.: Fluid Mechanics. An introduction to the theory of fluid flows. Springer-Verlag, Berlin, 2008
11.	Lee T.W.: Thermal and flow measurements. CRC Press, Taylor & Francis Group, 2008
12.	Arts T. et al.: Measurements techniques in fluid dynamics. Von Karman Institute Press, 1994
13.	Newland D.E.: Random vibrations, spectral & wavelet analysis. Longman, 1993
14.	Hinze J.O.: Turbulence. McGraw-Hill, New York, 1975
15.	http://prod.ceidg.gov.pl/