Uchwała Nr 13/2019
Senatu Politechniki Łódzkiej
z dnia 29 maja 2019 r.

w sprawie ustalenia programu kształcenia
w Interdyscyplinarnej Szkole Doktorskiej Politechniki Łódzkiej

Na podstawie art. 28 ust. 1 pkt 12 ustawy z dnia 20 lipca 2018 r. – Prawo o szkolnictwie wyższym i nauce (Dz. U. z 2018 r. poz. 1668, z późn. zm.) w związku z art. 291 ustawy z dnia 3 lipca 2018 r. – Przepisy wprowadzające ustawę – Prawo o szkolnictwie wyższym i nauce (Dz. U. z 2018 r. poz. 1669, z późn. zm.) uchwala się, co następuje:

§ 1. Ustala się program kształcenia w Interdyscyplinarnej Szkole Doktorskiej Politechniki Łódzkiej, stanowiący załącznik do uchwały.

§ 2. Uchwała wchodzi w życie z dniem 29 maja 2019 r.

Rektor
Politechniki Łódzkiej
Prof. dr hab. inż. Sławomir Wiak

Załącznik
do Uchwały Nr 13/2019 Senatu Politechniki Łódzkiej z dnia 29 maja 2019 r.
w sprawie ustalenia programu kształcenia
w Interdyscyplinarnej Szkole Doktorskiej Politechniki Łódzkiej

Program kształcenia
w Interdyscyplinarnej Szkole Doktorskiej Politechniki Łódzkiej

Program kształcenia w Interdyscyplinarnej Szkole Doktorskiej (ISD PŁ) oferuje 12 ścieżek kształcenia, które odpowiadają 12 dyscyplinom w 4 dziedzinach naukowych zgodnie z poniższą listą:

I. W dziedzinie nauk inżynieryjno-technicznych:
1. Inżynieria materiałowa
2. Inżynieria mechaniczna
3. Automatyka, elektronika i elektrotechnika
4. Informatyka techniczna i telekomunikacja
5. Inżynieria lądowa i transport
6. Architektura i urbanistyka
7. Inżynieria chemiczna

II. W dziedzinie nauk ścisłych i przyrodniczych:
8. Nauki chemiczne
9. Matematyka
10. Nauki fizyczne

III. W dziedzinie nauk rolniczych:
11. Technologia żywności i żywienia

IV. W dziedzinie nauk społecznych:
12. Nauki o zarządzaniu i jakości

1. Podstawowe założenia

Kształcenie prowadzone jest w języku angielskim w dyscyplinie wiodącej, którą kandydat deklaruje w momencie przystąpienia do rekrutacji do ISD PŁ. Program kształcenia w każdej dyscyplinie (tzw. „core curriculum and entrepreneurship – CCE") obejmuje:

1. *Podstawę programową dla danej dyscypliny* (8 ECTS)
2. *Przedmiot Przedsiębiorczość* (1 ECTS)

2. Ramowy program kształcenia

Skrót	core curicullum & entrepreneurship	liczba godz.	ECTS
CC	*Core curicullum*	*120*	*8*
E	*Entrepreneurship*	*15*	*1*
	Suma	**135**	**9**

3. Programowe efekty kształcenia

Efekty kształcenia zostały określone osobno dla każdego przedmiotu w ramach danej ścieżki kształcenia i znajdują się w załącznikach do Programu kształcenia w ISD PŁ.

Programowe efekty kształcenia	
Symbol	*Po zakończeniu przedmiotu doktorant potrafi:*
	Wiedza - zna i rozumie:
W1 ***P8S_EG***	Zakres i głębia – kompletność perspektywy poznawczej i zależności 1. w stopniu umożliwiającym rewizję istniejących paradygmatów – światowy dorobek, obejmujący podstawy teoretyczne oraz zagadnienia ogólne i wybrane zagadnienia szczegółowe – właściwe dla danej dyscypliny naukowej; 2. główne tendencje rozwojowe dyscyplin naukowych, w których odbywa się kształcenie; 3. metodologię badań naukowych zasady upowszechniania wyników działalności naukowej, także w trybie otwartego dostępu.
W2 ***P8S_WK***	Kontekst – uwarunkowania i skutki 1. fundamentalne dylematy współczesnej cywilizacji; 2. ekonomiczne, prawne, etyczne i inne istotne uwarunkowania działalności naukowej; 3. podstawowe zasady transferu wiedzy do sfery gospodarczej i społecznej oraz komercjalizacji wyników działalności naukowej i know-how związanego z tymi wynikami.
	Umiejętności – potrafi:
U1 ***P8S_UW***	Wykorzystanie wiedzy – rozwiązywane problemy i wykonywane zadania 1. wykorzystywać wiedzę z różnych dziedzin nauki lub dziedziny sztuki do twórczego identyfikowania, formułowania i innowacyjnego rozwiązywania złożonych problemów lub wykonywania zadań o charakterze badawczym, a w szczególności: a. definiować cel i przedmiot badań naukowych, formułować hipotezę badawczą, b. rozwijać metody, techniki i narzędzia badawcze oraz twórczo je stosować, c. wnioskować na podstawie wyników badań naukowych; 2. dokonywać krytycznej analizy i oceny wyników badań naukowych, działalności eksperckiej i innych prac o charakterze twórczym oraz ich wkładu w rozwój wiedzy; 3. transferować wyniki działalności naukowej do sfery gospodarczej i społecznej.
U2 ***P8S_UK***	Komunikowanie się – odbieranie i tworzenie wypowiedzi, upowszechnianie wiedzy w środowisku naukowym i posługiwanie się językiem obcym 1. komunikować się na tematy specjalistyczne w stopniu umożliwiającym aktywne uczestnictwo w międzynarodowym środowisku naukowym; 2. upowszechniać wyniki działalności naukowej, także w formach popularnych; 3. inicjować debatę; 4. uczestniczyć w dyskursie naukowym; 5. posługiwać się językiem obcym na poziomie B2 Europejskiego Systemu Opisu Kształcenia Językowego w stopniu umożliwiają cym uczestnictwo w międzynarodowym środowisku naukowym i zawodowym.
U3 ***P8S_UO***	Organizacja pracy – planowanie i praca zespołowa 1. planować i realizować indywidualne i zespołowe przedsięwzięcia badawcze lub twórcze, także w środowisku międzynarodowym.
U4 ***P8S_UU***	Uczenie się – planowanie własnego rozwoju i rozwoju innych osób 1. samodzielnie planować i działać na rzecz własnego rozwoju oraz inspirować i organizować rozwój innych osób; 2. planować zajęcia lub grupy zajęć i realizować je z wykorzystaniem nowoczesnych metod i narzędzi.
	Kompetencje społeczne - jest gotów do:
K1 ***P8S_KK***	Oceny – krytyczne podejście 1. krytycznej oceny dorobku w ramach danej dyscypliny naukowej lub artystycznej; 2. krytycznej oceny własnego wkładu w rozwój danej dyscypliny naukowej lub artystycznej; 3. uznawania znaczenia wiedzy w rozwiązywaniu problemów poznawczych i praktycznych.
K2 ***P8S_KO***	Odpowiedzialność – wypełnianie zobowiązań społecznych i działanie na rzecz interesu publicznego 1. wypełniania zobowiązań społecznych badaczy i twórców; 2. inicjowania działań na rzecz interesu publicznego; 3. myślenia i działania w sposób przedsiębiorczy
K3 ***P8S_KR***	Rola zawodowa – niezależność i rozwój etosu 1. podtrzymywania i rozwijania etosu środowisk badawczych i twórczych, w tym prowadzenia działalności naukowej w sposób niezależny i respektowania zasady publicznej własności wyników działalności naukowej, z uwzględnieniem zasad ochrony własności intelektualnej.

4. Lista załączników do Programu kształcenia w ISD PŁ:

Załącznik nr 1 do Programu Kształcenia w ISD PŁ – ścieżka kształcenia w dyscyplinie Inżynieria materiałowa
Załącznik nr 2 do Programu Kształcenia w ISD PŁ – ścieżka kształcenia w dyscyplinie Inżynieria mechaniczna
Załącznik nr 3 do Programu Kształcenia w ISD PŁ – ścieżka kształcenia w dyscyplinie Automatyka, elektronika i elektrotechnika
Załącznik nr 4 do Programu Kształcenia w ISD PŁ – ścieżka kształcenia w dyscyplinie Informatyka techniczna i telekomunikacja
Załącznik nr 5 do Programu Kształcenia w ISD PŁ – ścieżka kształcenia w dyscyplinie Inżynieria lądowa i transport
Załącznik nr 6 do Programu Kształcenia w ISD PŁ – ścieżka kształcenia w dyscyplinie Architektura i urbanistyka
Załącznik nr 7 do Programu Kształcenia w ISD PŁ – ścieżka kształcenia w dyscyplinie Inżynieria chemiczna
Załącznik nr 8 do Programu Kształcenia w ISD PŁ – ścieżka kształcenia w dyscyplinie Nauki chemiczne
Załącznik nr 9 do Programu Kształcenia w ISD PŁ – ścieżka kształcenia w dyscyplinie Matematyka
Załącznik nr 10 do Programu Kształcenia w ISD PŁ – ścieżka kształcenia w dyscyplinie Nauki fizyczne
Załącznik nr 11 do Programu Kształcenia w ISD PŁ – ścieżka kształcenia w dyscyplinie Technologia żywności i żywienia
Załącznik nr 12 do Programu Kształcenia w ISD PŁ – ścieżka kształcenia w dyscyplinie Nauki o zarządzaniu
Załącznik nr 13 do Programu Kształcenia w ISD PŁ – karta przedmiotu Przedsiębiorczość

Załącznik nr 1
do Programu Kształcenia w ISD PŁ –
ścieżka kształcenia w dyscyplinie
Inżynieria materiałowa

TRAINING PROGRAM IN DISCIPLINE: Materials Engineering

1. Basic information

Domain: Engineering and Technology
Discipline: Materials Engineering
Degree awarded: PhD in Materials Engineering
Program Coordinators:

Name: dr hab. inż. Hieronim Szymanowski, prof. PŁ
Institute: W1
Email: hieronim.szymanowski@p.lodz.pl
Name: dr hab. inż. Marcin Barburski
Institute: W4
Email: marcin.barburski@p.lodz.pl

2. Lecturers

No	Name and surname	Title/degree	Website/ORCID
1	Piotr Kula	prof. dr hab inż.	0000-0002-1796-9155
2	Bogdan Walkowiak	prof. dr hab.	0000-0003-4867-5456
3	Izabella Krucińska	prof. dr hab inż.	0000-0001-7233-9327
4	Ryszard Korycki	prof. dr hab inż.	0000-0002-1383-7999
5	Leszek Klimek	prof. dr hab inż.	0000-0003-3617-8225
6	Piotr Niedzielski	prof. dr hab. inż.	0000-0002-6966-9154
7	Iwona Frydrych	prof. dr hab. inż.	0000-0001-8331-5611
8	Katarzyna Grabowska	dr hab. inż.	0000-0002-8021-5428
9	Zbigniew Mikołajczyk	dr hab. inż.	0000-0002-5351-887X
10	Sławomir Sztajnowski	dr hab. inż.	0000-0001-8188-3017
11	Zbigniew Draczyński	dr hab. inż	0000-0002-4036-0559
12	Anna Sobczyk-Guzenda	dr hab. inż	0000-0003-1583-4238
13	Bożena Pietrzyk	dr hab. inż	0000-0002-8855-3763
14	Damian Batory	dr hab. inż.	0000-0002-6555-7657

15	Hieronim Szymanowski	dr. hab. inż.	0000-0002-4243-6342
16	Marcin Barburski	dr hab. inż.	0000-0002-8127-477X
17	Magdalena Gliścińska	dr hab.	0000-0002-4503-5691
18	Jacek Sawicki	dr hab. inż.	0000-0001-9147-7338
19	Łukasz Kaczmarek	dr hab. inż.	0000-0002-6163-3608
20	Mariusz Dudek	dr hab. inż.	0000-0003-4213-7673
21	Konrad Dybowski	dr hab. inż.	0000-0003-4017-3830
22	Jacek Grabarczyk	dr hab. inż.	0000-0003-0155-2432
23	Łukasz Kołodziejczyk	dr hab. inż.	0000-0002-4704-4188
24	Emilia Wołowiec-Korecka	dr hab. inż.	0000-0003-0978-3948
25	Michał Puchalski	dr hab. inż.	0000-0001-7848-9801
26	Dawid Stawski	dr hab. inż.	0000-0002-7916-0239
27	Piotr Kulpiński	dr hab. inż.	0000-0002-6730-3220
28	Marek Kozicki	dr hab. inż.	0000-0002-8396-4344
29	Michał Frydrysiak	dr hab. inż.	0000-0002-6004-8976
30	Małgorzata Matusiak	dr hab. inż.	0000-0002-9105-1166
31	Magdalena Tokarska	dr hab. inż.	0000-0001-8102-1230
32	Jacek Leśnikowski	dr hab. inż.	0000-0002-4938-6835
33	Wojciech Pawlak	dr inż.	0000-0001-6461-523X
34	Radomir Atraszkiewicz	dr inż.	0000-0002-1662-8287
35	Robert Pietrasik	dr inż.	0000-0001-8186-9231
36	Sebastian Lipa	dr inż.	0000-0002-8971-3685
37	Sebastian Miszczak	dr inż.	0000-0002-6074-9529
38	Witold Szymański	dr inż.	0000-0002-4738-5847
39	Dorota Bociaga	dr inż.	0000-0001-6230-4219
41	Marcin Makówka	dr inż.	0000-0003-1685-3174
42	Dorota Rylska	dr inż.	0000-0002-7593-9763
43	Witold Jakubowski	dr	0000-0003-1751-609X
44	Jacek Rutkowski	dr inż.	0000-0002-9775-0187
45	Lucyna Herczyńska	dr inż.	0000-0003-4278-5988
46	Bartłomiej Januszewicz	dr inż.	0000-0001-8735-0975

47	Maria Cybulska	dr	0000-0002-9364-8820

3. Training demand

PhD training in the field of Materials Engineering prepare graduates for an employment in scientific laboratories, research and development establishments, universities – and technical universities in particular – as well as in management positions in the industry. The aim of the studies comprises an introduction of candidate to the newest scientific achievements and research results in the area chosen as the subject of her/his PhD thesis. Currently, there is a substantial demand for such graduates, well prepared for teaching and conducting research at technical universities. At these universities, a "generation gap" is observed among their employees and the graduate school should fill that gap.

Within the frames of the PhD level graduate school, candidates acquire specialized knowledge in the field of Materials Engineering, broaden their cognitive capabilities and collect experiences necessary in research work. Simultaneously, they acquire teaching and organizational experiences and develop scientific contacts through participation in seminars and conferences, both domestic and external.

After finishing the training and a completion of the PhD thesis, a candidate is equipped with a broadly specialized knowledge, an ability to perform scientific collaboration with domestic laboratories, university teaching experience and analytical abilities necessary in research work. Those candidates who do not plan scientific career shall utilize their cognitive abilities as well as teaching and organizational experiences, gained in the frames of the graduate school, in the course of their further professional employment.

4. Detailed entry requirements

Persons applying for an admission to the IDS in the area of Materials Engineering must possess MS qualifications acquired in one of the following areas: materials engineering, mechanical engineering, chemistry, biology, physics, mechanics and machinery construction, physics and chemistry of textile science and design as well as biology. In particular cases, determined by an appropriate resolution of the Department Council concerning admission to the PhD graduate school, candidates possessing MS qualifications in the area of medical sciences may also apply for admission.

5. Teaching methods

Lectures, exercises, laboratories, projects, scientific seminaries, distance education.

6. Graduate's profile

A Materials Engineering IDS graduate knows and understands the world's scientific and creative achievements in the field of Materials Engineering and the resulting practical implications in materials engineering applications. One is able to undertake an analysis and a creative synthesis of scientific achievements in order to identify and solve research problems as well as those related to innovative and creative activity. One is able to enrich the mentioned achievements, plan personal development and inspire others to do so, exchange experience and ideas within polish and international environment and what is more is ready to make an independent research in order to

expand scientific and creative achievements, face the professional and public challenges taking into account ethics and responsibility for its results and also to form a way of a proper behavior.

A strategic aim of the teaching programme is to prepare highly qualified personnel for scientific and innovative industry needs to work in advisory and project units, trading companies of engineering materials and its research equipment and also in laboratories related to quality control and certification of engineering materials. It is possible thanks to innovative and interdisciplinary scientific research and their application in a personnel preparation programme in compliance with “knowledge based community” model. In particular, the aim of the training programme is to prepare a specialist who knows and understands the achievements of his field of interest at the level which allows him to revise current paradigms, but also understands the fundamental dilemmas of the present civilization; economical, juridical and other important in the field of research activity. Besides, the aim is to prepare a graduate student to use his broad knowledge to identify, formulate and solve complex problems or execute research tasks. Likewise, the aim is to create an awareness of the need of disseminating research results, initiating debates, participating in science discourses, using foreign language at the level allowing to take part in an international scientific and professional environment, as well as planning and pursuing an individual and group research or creative undertakes, also in an international environment.

Graduate understands a need of developing his qualifications by taking part in trainings, courses and also doing own scientific research preserving all ethical standards and is ready to solve problems related to Materials Engineering, knowing the present state of art.

7. Training plan

Semester 1									
No	Subcategory	Subject							ECTS
			L	T	L	P	S	Σ	
1	E	Entrepreneurship	15					15	1
2	CC1	World trends in Materials Engineering	15					15	1
3	CC2	Research Methods of Materials Science	15					15	1
Total								45	3
Semester 2									
No	Subcategory	Subject							ECTS
			L	T	L	P	S	Σ	
1	CC3	Surface Engineering	15					15	1
2	CC4	Construction materials I	15					15	1
3	CC5	Construction materials II	15					15	1
Total								45	3
Semester 3									
No	Subcategory	Subject							ECTS

			L	T	L	P	S	Σ	
1	CC6	Composite technologies	15					15	1
2	CC7	Numerical Analysis for Engineering	5		10			15	1
3	CC8	Strength of Materials	15					15	1
Total								45	3
TOTAL								**135**	**9**

<table>
<tr><td>Course code</td><td>CC1</td></tr>
<tr><td>Type and description</td><td></td></tr>
<tr><td>ECTS credit</td><td>1</td></tr>
<tr><td>Course name</td><td>World trends in materials engineering</td></tr>
<tr><td>Course name in Polish</td><td>Światowe trendy w inżynierii materiałowej</td></tr>
<tr><td>Language of instruction</td><td>English</td></tr>
<tr><td>Course level</td><td>8 PRK</td></tr>
<tr><td>Course coordinator</td><td>Prof. Kula Piotr, phD., D.Sc.</td></tr>
<tr><td>Course instructors</td><td>DSc eng. Zbigniew Draczynski</td></tr>
<tr><td>Delivery methods and course duration</td><td>
<table>
<tr><th></th><th>Lecture</th><th>Tutorials</th><th>Laboratory</th><th>Project</th><th>Seminar</th><th>Other</th><th>Total of teaching hours during semester</th></tr>
<tr><td>Contact hours</td><td>15</td><td></td><td></td><td></td><td></td><td>0</td><td>15</td></tr>
<tr><td>E-learning</td><td>No</td><td>No</td><td>No</td><td>No</td><td>No</td><td>No</td><td></td></tr>
<tr><td>Assessment criteria (weightage)</td><td>0,00</td><td></td><td></td><td></td><td></td><td>0,00</td><td></td></tr>
</table>
</td></tr>
<tr><td>Course objective</td><td>The aim of the course is:
1. Introduce PhD to the world trends in materials engineering,
2. Enable students to acquiring knowledge of new trends in the field of engineering polymer materials.</td></tr>
<tr><td>Learning outcomes</td><td>PhD student is able;
1. Describe the state of art and world trends in Materials Engineering,
2. Define basic mechanical properties of engineering materials.
3. Define methods for molding of engineering materials properties
4. Classify polymers used in material engineering with regard to chemical structure, their physicochemical properties and processing capabilities. – effects - W1 P8S_EG, U1 P8S_UW2. 4</td></tr>
<tr><td>Assessment methods</td><td>Verification methods of learning outcomes
effects W1 P8S_EG, U1 P8S_UW2. 4- written exam
The final grade consists of:
The result of the written exam - 100%</td></tr>
<tr><td>Prerequisites</td><td></td></tr>
<tr><td>Course content with delivery methods</td><td>LECTURE
1. Etymology of “engineering materials” and importance of it for modern technology,
2. Basic definition of engineering materials: metals, ceramic, polymers, composites,
3. Chemical bounds and their relationship with materials properties,
4. Mechanical properties of materials,
5. Structural defects and their influence on materials properties,
6. Surface layer and its technological modification,
7. Industrial equipment for surface engineering,
8. World trends in heat treatment and thermo-chemical treatment,
9. Basic knowledge in the field of macromolecular compounds.
10. Polymers in a condensed state.
11. Degradation of macromolecular compounds.
12. Configuration of the macromolecule. The size and shape of the macromolecule.
13. Polymer solutions. Polydispersity of polymers. Functions of molecular weight distribution.</td></tr>
</table>

	14. Innovative techniques of processing polymeric materials
Basic reference materials	1. The lecturer's material, 2. Blicharski M.: Wstęp do inżynierii materiałowej. WNT, Warszawa, 1998. 3. Połowiński S.: Chemia fizyczna polimerów, Wydawnictwo Politechniki Łódzkiej, Łódź, 2001 r. 4. Praca zbiorowa, Chemia polimerów, tom I-III, Oficyna Wydawnicza Politechniki Warszawskiej, Warszawa 1997 r.
Other reference materials	1. Kula P.: Inżynieria warstwy wierzchniej. Monografia PŁ, Łódź, 2000, 2. Guy A.G., "Wprowadzenie do nauki o materiałach", PWN 1977 3. Przybyłowicz K., "Podstawy teoretyczne metaloznawstwa", WNT Warszawa 1999
Average student workload outside classroom	10
Comments	
Last update	

<table>
<tr><td>Course code</td><td>CC2</td></tr>
<tr><td>Type and description</td><td></td></tr>
<tr><td>ECTS credit</td><td>1</td></tr>
<tr><td>Course name</td><td>Research Methods of Materials Science</td></tr>
<tr><td>Course name in Polish</td><td>Metody badań materiałów</td></tr>
<tr><td>Language of instruction</td><td>English</td></tr>
<tr><td>Course level</td><td>8 PRK</td></tr>
<tr><td>Course coordinator</td><td>Dr hab. Michał Puchalski</td></tr>
<tr><td>Course instructors</td><td></td></tr>
<tr><td>Delivery methods and course duration</td><td>
<table>
<tr><th></th><th>Lecture</th><th>Tutorials</th><th>Laboratory</th><th>Project</th><th>Seminar</th><th>Other</th><th>Total of teaching hours during semester</th></tr>
<tr><td>Contact hours</td><td>0</td><td></td><td></td><td></td><td></td><td>0</td><td>15</td></tr>
<tr><td>E-learning</td><td>No</td><td>No</td><td>No</td><td>No</td><td>No</td><td>No</td><td></td></tr>
<tr><td>Assessment criteria (weightage)</td><td>0,00</td><td></td><td></td><td></td><td></td><td>0,00</td><td></td></tr>
</table>
</td></tr>
<tr><td>Course objective</td><td>Objective of the course

The objective of the course is to enable the acquisition of knowledge including the principle of work and application of selected measurement methods applied in material engineering.</td></tr>
<tr><td>Learning outcomes</td><td>Doctoral student on completion of the course:

1. knows and understands the principle of functioning and the area of application of research methods applied in materials engineering W1_P8S_EG

2. is able to develop methods, techniques and research tools for assessing the physical structure of materials and creatively plan their application U1_P8S_UW

3. is able to critically analyze and evaluate the results of tests on the properties of engineering materials U1_P8S_UW</td></tr>
<tr><td>Assessment methods</td><td>Methods of verifying of learning outcomes
Learning outcome 1- written colloquium
Learning outcomes 2, 3 – laboratory report
Final mark consist of:
Written colloquium score - 80%.
Laboratory report - 60%.</td></tr>
<tr><td>Prerequisites</td><td></td></tr>
<tr><td>Course content with delivery methods</td><td>Laboratory
1. Determination of crystalline structure of materials and nanomaterials by using of X-ray diffractometer.
2. Analysis of topography of materials by using of atomic force microscope.
3. Investigation of the morphology of materials by using of a high resolution scanning electron microscope.
4. Evaluation of thermal phase transition of polymeric materials by using of differential scanning calorimetry
5. Analysis of the chemical composition of materials surface by the using of X-ray</td></tr>
</table>

	microanalysis.
Basic reference materials	1. A. Foster, W. Hofer, Scanning Probe Microscopy: Atomic Scale Engineering by Forces and Currents, Springer, 2006 2. A.R. Clarke, C.N. Eberhardt, Microscopy techniques for materials science, CRC Press LLC, 2000 3. K. Sikorski, Quantitative X-ray Microanalysis Beyond the Resolution of the Method, OWPW, 2009 4. W.M. Groenewoud Characterisation of Polymers by Thermal Analysis, Elsevier, 2001 5. M. Birkholz, Thin Film Analysis by X-Ray Scattering, WILEY-VCH Verlag GmbH & Co. 2006
Other reference materials	1. Scanning Probe Microscopy: Training Notebook, Digital Instruments Veeco Metrology Group, 1999 2. N. Yao, Z. L. Wang, HANDBOOK OF MICROSCOPY FOR NANOTECHNOLOGY, Kluwer Academic Publishers, 2005 3. M. Puchalski, P.J. Kowalczyk, Z. Klusek, W. Olejniczak. „The applicability of global and surface sensitive techniques to characterization of silver nanopartilces for Ink-Jet printing technology" in „Silver nanoparticles" David Pozo Perez Ed., In-Tech, 2010 4. M. Puchalski, P. Dabrowski, W. Olejniczak, P. Krukowski, P. Kowalczyk, K. Polański. „The study of nanoparticles of silver by means of SEM, EDX, STM" Materials Science – Poland, Vol. 25, 2007, 473 – 478.
Average student workload outside classroom	10 hour
Comments	
Last update	

<table>
<tr><td>Course code</td><td>CC3</td></tr>
<tr><td>Type and description</td><td></td></tr>
<tr><td>ECTS credit</td><td>1</td></tr>
<tr><td>Course name</td><td>Surface Engineering</td></tr>
<tr><td>Course name in Polish</td><td>Inżynieria powierzchni</td></tr>
<tr><td>Language of instruction</td><td>English</td></tr>
<tr><td>Course level</td><td>8 PRK</td></tr>
<tr><td>Course coordinator</td><td>Prof. Kula Piotr, phD., D.Sc.</td></tr>
<tr><td>Course instructors</td><td>Prof. Kula Piotr, phD., D.Sc.</td></tr>
<tr><td>Delivery methods and course duration</td><td>
<table>
<tr><th></th><th>Lecture</th><th>Tutorials</th><th>Laboratory</th><th>Project</th><th>Seminar</th><th>Other</th><th>Total of teaching hours during semester</th></tr>
<tr><td>Contact hours</td><td>15</td><td></td><td></td><td></td><td></td><td>0</td><td>15</td></tr>
<tr><td>E-learning</td><td>No</td><td>No</td><td>No</td><td>No</td><td>No</td><td>No</td><td></td></tr>
<tr><td>Assessment criteria (weightage)</td><td>1</td><td></td><td></td><td></td><td></td><td>0,00</td><td></td></tr>
</table>
</td></tr>
<tr><td>Course objective</td><td>Course objective:

1. Methods and choice criteria of materials properties for engineering applications,
2. Theoretical background of kinetics and control of thermo-chemical treatment,
3. Theory and practise of coating technology.</td></tr>
<tr><td>Learning outcomes</td><td>Ph.D. student is able:

1. Analyse service conditions and properly select materials and treatments to meet them,
2. Describe and to on-line monitor parameters of thermo-chemical treatment,
3. Recognise modern coating processes and properly apply them for engineering cases,
4. Practically use the computer software for thermal and thermo-chemical processes modelling and simulation,
5. Experimentally confirm results of mentioned above computer simulations,</td></tr>
<tr><td>Assessment methods</td><td>Outcomes 1-5 – control test (60%),

Outcomes 1-5 – presentation (40%)</td></tr>
<tr><td>Prerequisites</td><td>Basic Materials Science</td></tr>
<tr><td>Course content with delivery methods</td><td>Lecture:

1. Protective gas mixtures for heat treatment of metals. Theory and practise.
2. Thermo-chemical equilibrium. Phenomena on the sold/gas(liquid) interface.
3. Pre-treatments for thermochemical processes.
4. Kinetics and monitoring of gas carburizing.
5. Kinetics and monitoring of vacuum carburizing.
6. Kinetics and monitoring of nitriding.
7. Multiphase surface layers which protect against scuffing.</td></tr>
</table>

	8. Boriding of steel. 9. Ions implantation. 10. Sol-gel ceramic coatings. 11. CVD and PA CVD coatings, 12. PVD coatings. 13. Arc and Laser cladding. 14. Multiplex surface layers. 15. Criteria of proper application of surface engineering processes.
Basic reference materials	1. The lecturer's draft. 2. ASM Metals Handbook, vol.4. 1991
Other reference materials	1. **Advanced Surface Coatings: a Handbook of Surface Engineering. Autor:** **A. Matthews**
Average student workload outside classroom	10 h
Comments	
Last update	

<table>
<tr><td>Course code</td><td>CC4</td></tr>
<tr><td>Type and description</td><td></td></tr>
<tr><td>ECTS credit</td><td>1</td></tr>
<tr><td>Course name</td><td>Construction materials II</td></tr>
<tr><td>Course name in Polish</td><td>Materiały konstrukcyjne II</td></tr>
<tr><td>Language of instruction</td><td>English</td></tr>
<tr><td>Course level</td><td>8 PRK</td></tr>
<tr><td>Course coordinator</td><td>dr hab. inż. Hieronim Szymanowski</td></tr>
<tr><td>Course instructors</td><td>Dr inż. Adam Rylski, Dr inż Marcin Makówka, D inż. Wojciech Pawlak</td></tr>
<tr><td>Delivery methods and course duration</td><td>
<table>
<tr><th></th><th>Lecture</th><th>Tutorials</th><th>Laboratory</th><th>Project</th><th>Seminar</th><th>Other</th><th>Total of teaching hours during semester</th></tr>
<tr><td>Contact hours</td><td>10</td><td></td><td>5</td><td></td><td></td><td>0</td><td>15</td></tr>
<tr><td>E-learning</td><td>No</td><td>No</td><td>No</td><td>No</td><td>No</td><td>No</td><td></td></tr>
<tr><td>Assessment criteria (weightage)</td><td>70%</td><td></td><td>30%</td><td></td><td></td><td></td><td>100%</td></tr>
</table>
</td></tr>
<tr><td>Course objective</td><td>1. Introduce modern engineering materials that are widely applicable in technology
2. Explain issues related with selection of modern engineering materials for structural and functional components
3. Adopt the method of preparation of the</td></tr>
<tr><td>Learning outcomes</td><td>After the course student is able to:
1.Describe the properties and functionalities of selected modern ones engineering materials, in particular such metals and memory shape, superplastic alloys, metallic glasses, superhard ceramics and enamel materials as well as carbon materials.
2. Provide comprehensive information about modern engineering materials from literature, databases and other Polish and foreign sources
3. Is able to identify and formulate the specification of simple engineering tasks related to design, construction, selection of materials and manufacturing technologies,</td></tr>
<tr><td>Assessment methods</td><td>All learning outcomes will be verified on the basis of written ones tests, oral answers and reports from the laboratory.
The final grade consists of:
The result of the written exam - 70%
Report and activity in classes – 30%</td></tr>
<tr><td>Prerequisites</td><td>Knowledge of the basics of materials science</td></tr>
<tr><td>Course content with delivery methods</td><td>LECTURE
Construction materials for machines and devices. Stainless steel. Aluminum alloys. Titan and alloys. Superalloys. Shape memory materials. Ceramics . Construction ceramics and cermets. Super hard materials. Ceramic functional materials with special properties. Carbon materials.
LABORATORY</td></tr>
</table>

	Preparation of functional coating (ceramic) PVD and PE CVD technology.
Basic reference materials	1. L.A. Dobrzanski: Metaloznawstwo z podstawami nauki o materiałach. WNT, 1999. 2. Ashby M., Shercliff H., Cebon D., Inżynieria Materiałowa Tom 1 i 2, Wyd. Galaktyka, 2011 3. K.Oczoś;Kształtowanie ceramicznych materiałów technicznych; Wydawnictwo Politechniki Rzeszowskiej, 1996 4. Ciszewski B., Przetakiewicz W.:Nowoczesne materiały w technice; Bellona, Warszawa, 1993
Other reference materials	
Average student workload outside classroom	10 h
Comments	
Last update	

<table>
<tr><td>Course code</td><td>CC5</td></tr>
<tr><td>Type and description</td><td>CC - the core curriculum for the discipline Materials Engineering</td></tr>
<tr><td>ECTS credit</td><td>1</td></tr>
<tr><td>Course name</td><td>Construction materials II</td></tr>
<tr><td>Course name in Polish</td><td>Materiały konstrukcyjne II</td></tr>
<tr><td>Language of instruction</td><td>English</td></tr>
<tr><td>Course level</td><td>8 PRK</td></tr>
<tr><td>Course coordinator</td><td>dr hab. inż. Marcin Barburski</td></tr>
<tr><td>Course instructors</td><td></td></tr>
<tr><td>Delivery methods and course duration</td><td>
<table>
<tr><th></th><th>Lecture</th><th>Tutorials</th><th>Laboratory</th><th>Project</th><th>Seminar</th><th>Other</th><th>Total of teaching hours during semester</th></tr>
<tr><td>Contact hours</td><td>10</td><td></td><td>5</td><td></td><td></td><td>0</td><td>15</td></tr>
<tr><td>E-learning</td><td>No</td><td>No</td><td>No</td><td>No</td><td>No</td><td>No</td><td></td></tr>
<tr><td>Assessment criteria (weightage)</td><td>70%</td><td></td><td>30%</td><td></td><td></td><td></td><td>100%</td></tr>
</table>
</td></tr>
<tr><td>Course objective</td><td>The aim of the course is to broaden knowledge by learning about the construction, properties and applications of unconventional, lightweight, textile construction materials</td></tr>
<tr><td>Learning outcomes</td><td>A doctoral candidate after completing the course can:
1. Adapt the structure and structure of the material for special constructional
2. describe the construction materials,
3. discuss and describe the impact of the raw material, the structure of the starting materials and the technology used on the properties of the construction materials</td></tr>
<tr><td>Assessment methods</td><td>effects 1-2 - written exam from the lecture
effect 3 - laboratory report
The final grade consists of:
The result of the written exam - 70%
Report and activity in classes – 30%</td></tr>
<tr><td>Prerequisites</td><td>Second level studies</td></tr>
<tr><td>Course content with delivery methods</td><td>LECTURE
Application and classification of construction materials, technologies for construction materials
LABORATORY
Realization of construction material using a vacuum bag</td></tr>
<tr><td>Basic reference materials</td><td>- Blicharski Marek „Inżynieria materiałowa” Wydawnictwo Naukowe PWN W-wa 2019 ISBN: 9788301193300
Michae Ashby, Hugh Shercliff, David Cebon “Inżynieria materiałowa” Galaktyka 2011
- Wacław Królikowski Polimerowe kompozyty konstrukcyjne Wydawnictwo Naukowe PWN 2012
- Żuchowska D.: Polimery konstrukcyjne, Wydawnictwa Naukowo-Techniczne, W-wa 2000</td></tr>
<tr><td>Other reference materials</td><td>- Królikowski W.: Tworzywa wzmocnione i włókna wzmacniające. WNT W-wa 1988
- Nowacki J.: Materiały kompozytowe, Wydawnictwo Politechniki Łódzkiej, Łódź 1993
Dobrzański L.A.: Podstawy nauki o materiałach, Wydawnictwo Politechniki Śląskiej, Gliwice 2012</td></tr>
<tr><td>Average student workload outside classroom</td><td>10 h</td></tr>
</table>

Comments	
Last update	

<table>
<tr><td>Course code</td><td>CC6</td></tr>
<tr><td>Type and description</td><td>CC - the core curriculum for the discipline Materials Engineering</td></tr>
<tr><td>ECTS credit</td><td>1</td></tr>
<tr><td>Course name</td><td>Composite technologies</td></tr>
<tr><td>Course name in Polish</td><td>Technologie kompozytów</td></tr>
<tr><td>Language of instruction</td><td>English</td></tr>
<tr><td>Course level</td><td>8 PRK</td></tr>
<tr><td>Course coordinator</td><td>Prof. dr hab. inż. Izabella Krucińska</td></tr>
<tr><td>Course instructors</td><td>Dr hab. inż. Eulalia Gliścińska</td></tr>
<tr><td>Delivery methods and course duration</td><td>
<table>
<tr><th></th><th>Lecture</th><th>Tutorials</th><th>Laboratory</th><th>Project</th><th>Seminar</th><th>Other</th><th>Total of teaching hours during semester</th></tr>
<tr><td>Contact hours</td><td>7</td><td></td><td>8</td><td></td><td></td><td>0</td><td>15</td></tr>
<tr><td>E-learning</td><td>No</td><td>No</td><td>No</td><td>No</td><td>No</td><td>No</td><td></td></tr>
<tr><td>Assessment criteria (weightage)</td><td>60%</td><td></td><td></td><td></td><td></td><td>40%</td><td></td></tr>
</table>
</td></tr>
<tr><td>Course objective</td><td>The aim of the course is to enable students to acquire knowledge and skills in the field of technologies of structural composites reinforced with fibrous prepregs.</td></tr>
<tr><td>Learning outcomes</td><td>A doctoral candidate after completing the course can:
1. describe the structure of composite materials, W1, P8S_EG; U1, P8S_UW
2. describe the technologies of composites with various matrices, W1, P8S_EG; U1, P8S_UW
3. discuss and describe the impact of the raw material, the structure of the starting materials and the technology used on the properties of the composite, W1, P8S_EG; U1, P8S_UW</td></tr>
<tr><td>Assessment methods</td><td>effects 1-2 - written exam from the lecture
effect 3 - colloquium and laboratory report

The final grade consists of:
The result of the written exam - 60%
Presentation – 40%</td></tr>
<tr><td>Prerequisites</td><td>Second level studies</td></tr>
<tr><td>Course content with delivery methods</td><td>LECTURE
Classification of composite materials. Constructional polymers. Additives for polymers that improve their properties. Technologies of polymer composites based on thermoplastics. Technologies of polymer composites based on thermosetting plastics. Technologies of polymer composites based on chemically hardened resins. Test methods for the properties of polymer composites. Technology of metal composites. Fiber-reinforced metal composites. Composite technologies based on ceramic matrix and ceramic-metal composites.
LABORATORY
1. Study of the influence of the reinforcing material contribution on the strength properties of a composite of a standard thickness.
2. Formation of composites on a polymer matrix using different forms of reinforcement and matrix
3. Evaluation of the quality of composites</td></tr>
<tr><td>Basic reference</td><td>1. Śleziona J.: Podstawy technologii kompozytów. Wydawnictwo Politechniki Śląskiej, Gliwice 1998</td></tr>
</table>

materials	2. Królikowski W.: Tworzywa wzmocnione i włókna wzmacniające. WNT W-wa 1988 3. Konsztowicz K.: Kompozyty wzmacniane włóknami. Podstawy technologii. Skrypty uczelniane - Akademia Górniczo-Hutnicza im. S. Staszica w Krakowie, Kraków 1983 4. Nowacki J.: Materiały kompozytowe, Wydawnictwo Politechniki Łódzkiej, Łódź 1993 5. Wilczyński A.: Polimerowe kompozyty włókniste, W N-T, W-wa 1996 6. Przybyłowicz K., Przybyłowicz J.: Repetytorium z materiałoznawstwa, Politechnika Świętokrzyska, Kielce 1996 7. Żuchowska D.: Polimery konstrukcyjne, Wydawnictwa Naukowo-Techniczne, W-wa 2000 8. Dobrzański L.A.: Podstawy nauki o materiałach, Wydawnictwo Politechniki Śląskiej, Gliwice 2012
Other reference materials	1. Łaskawiec J., Michalik R.: Zagadnienia teoretyczne i aplikacyjne w implantach. Wydawnictwo Politechniki Śląskiej, Gliwice 2002
Average student workload outside classroom	10 h
Comments	
Last update	

<table>
<tr><td>Course code</td><td>CC7</td></tr>
<tr><td>Type and description</td><td></td></tr>
<tr><td>ECTS credit</td><td>1</td></tr>
<tr><td>Course name</td><td>Numerical Analysis for Engineering</td></tr>
<tr><td>Course name in Polish</td><td>Komputerowa analiza numeryczna dla inżynierów</td></tr>
<tr><td>Language of instruction</td><td>English</td></tr>
<tr><td>Course level</td><td>8 PRK</td></tr>
<tr><td>Course coordinator</td><td>Dr hab. inz. Jacek Sawicki, prof. PŁ</td></tr>
<tr><td>Course instructors</td><td>Dr inz Radomir Atraszkiewicz, Dr inz Sebastian Lipa</td></tr>
<tr><td>Delivery methods and course duration</td><td>
<table>
<tr><th></th><th>Lecture</th><th>Tutorials</th><th>Laboratory</th><th>Project</th><th>Seminar</th><th>Other</th><th>Total of teaching hours during semester</th></tr>
<tr><td>Contact hours</td><td>0</td><td></td><td>15</td><td></td><td></td><td>0</td><td>15</td></tr>
<tr><td>E-learning</td><td>No</td><td>No</td><td>No</td><td>No</td><td>No</td><td>No</td><td></td></tr>
<tr><td>Assessment criteria (weightage)</td><td>0,00</td><td></td><td></td><td></td><td></td><td>0,00</td><td></td></tr>
</table>
</td></tr>
<tr><td>Course objective</td><td>Introduction with the questions of numerical modelling and the computer analysis of physical phenomena</td></tr>
<tr><td>Learning outcomes</td><td>The doctoral candidate will be able to:
1. use modern computer techniques - effects U4 P8S_UU
2. plan computational algorithms - effects U4 P8S_UU
3. construct the geometry and discrete model - the effects U4 P8S_UU
4. identify the boundary and initial conditions - the effects U1 P8S_UW
5. interpret and analyze the results of calculations - the effects U1 P8S_UW</td></tr>
<tr><td>Assessment methods</td><td>Verification methods of learning outcomes:
effect U1 P8S_UW, U4 P8S_UU - project design and presentation
The final grade consists of:
Projects - 80%
Presentation - 20%</td></tr>
<tr><td>Prerequisites</td><td>Basic computer usage; the physics and strength of materials knowledge</td></tr>
<tr><td>Course content with delivery methods</td><td>THE LABORATORY
Coupled analyzes FSI (Workbench, Ansys, CFX)
1. Building of geometrical patternel on basis of the analysis of real objects
2. Building of discreet patternel for chosen cases of definite physical phenomena
3. Defining shore and initial conditions for chosen cases
4. The examples analysis of chosen physical phenomena settled during
5. The examples analysis of chosen nonstationary physical phenomena
6. The analysis of the received results of computer simulations</td></tr>
<tr><td>Basic reference materials</td><td>1. The lecturer's material,
2. Technical documentation of the software - ANSYS-CFX,
3. Database of software examples - ANSYS-CFX. www.ansys.com</td></tr>
<tr><td>Other reference materials</td><td></td></tr>
<tr><td>Average student workload outside classroom</td><td>10h</td></tr>
</table>

Comments	
Last update	

<table>
<tr><td>Course code</td><td>CC8</td></tr>
<tr><td>Type and description</td><td>CC – core curriculum for the discipline Materials Engineering</td></tr>
<tr><td>ECTS credit</td><td>1</td></tr>
<tr><td>Course name</td><td>Strength of Materials</td></tr>
<tr><td>Course name in Polish</td><td>Wytrzymałość materiałów</td></tr>
<tr><td>Language of instruction</td><td>English</td></tr>
<tr><td>Course level</td><td>8 PRK</td></tr>
<tr><td>Course coordinator</td><td>Prof. dr hab. inż. Ryszard Korycki</td></tr>
<tr><td>Course instructors</td><td>Prof. dr hab. inż. Ryszard Korycki</td></tr>
<tr><td>Delivery methods and course duration</td><td>
<table>
<tr><th></th><th>Lecture</th><th>Tutorials</th><th>Laboratory</th><th>Project</th><th>Seminar</th><th>Other</th><th>Total of teaching hours during semester</th></tr>
<tr><td>Contact hours</td><td>8</td><td></td><td>7</td><td></td><td></td><td>0</td><td>15</td></tr>
<tr><td>E-learning</td><td>No</td><td>No</td><td>No</td><td>No</td><td>No</td><td>No</td><td></td></tr>
<tr><td>Assessment criteria (weightage)</td><td>0,50</td><td></td><td>0,50</td><td></td><td></td><td>0,00</td><td></td></tr>
</table>
</td></tr>
<tr><td>Course objective</td><td>Course objective
1. The aim of the course is to enable PhD students to acquire knowledge in assessment of strength of materials.</td></tr>
<tr><td>Learning outcomes</td><td>After the finished course the PhD student is able to:
1. Model the stress and strain of both elastic materials and textile materials subjected to tension, torsion and bending for isotropic, orthotropic and anisotropic materials – effects W1, U1.
2. Determine the physical and mathematical models, as well as solve the mathematical model; Visualize of state fields - effects W1, U1.
3. Determine the influence of external conditions (heat, moisture) on the distribution of state variables – effects W1, U1.</td></tr>
<tr><td>Assessment methods</td><td>Assessments methods:
Effect W1 - colloquium covering the tutorials material
Effect U1 - assessment of laboratory material
Final grade is a sum of::
grade of tutorial assessment 50%
grade of assessment covering laboratory material 50%</td></tr>
<tr><td>Prerequisites</td><td>None</td></tr>
<tr><td>Course content with delivery methods</td><td>TUTORIAL
1. Displacements, stress, strain and strength criterion. Tension of prismatic bars. Torsion of circular bars. Diagrams of torsional moments. Bending of prismatic bars. Theory of clear simple torsion. Isotropic, orthotropic, anisotropic materials and their influence on strain distribution.
2. Modeling of strength problems. Normal forces and stresses during torsion. Torsional stresses and torsional angle. Internal forces, bending moments.
3. Influence of external conditions (heat, moisture) on the material. Change of material characteristics under influence of heat, moisture and other factors.
LABORATORY
1. Tension, torsion and bending of complex structures (elements composed of a few materials, phase change materials etc.). Determination of strain and stress distribution.</td></tr>
</table>

Basic reference materials	Tutorial material, 1. Leyko J.: Mechanika ogólna - tom 1, 2 i 3. PWN, Warszawa, każde wydanie. 2. Niezgodziński M.E., Niezgodziński T.: Wytrzymałość materiałów. PWN, Warszawa, każde wydanie po 1990
Other reference materials	Niezgodziński M.E., Niezgodziński T.: Zbiór zadań z wytrzymałości materiałów. PWN, Warszawa, każde wydanie po 1990
Average student workload outside classroom	10 h
Comments	None
Last update	

Załącznik nr 2
do Programu Kształcenia w ISD PŁ –
ścieżka kształcenia w dyscyplinie
Inżynieria mechaniczna

TRAINING PROGRAM IN DISCIPLINE: Mechanical Engineering

1. Basic information

Domain: Engineering and Technology
Discipline: Mechanical Engineering
Degree awarded: PhD in Mechanical Engineering
Program Coordinator: TBA
Name:
Institute:
Email:

2. Lecturers

No	Name and surname	Title/degree	Website/ORCID
1	Awrejcewicz Jan	prof.	0000-0003-0387-921X
2	Maria Kotełko	prof.	0000-0001-7784-4349
3	Przemysław Perlikowski	prof.	0000-0003-0117-4451
4	Leszek Podsędkowski	prof.	0000-0003-2315-3109
5	Andrzej Stefański	prof.	0000-0002-3210-5080
6	Damian Batory	dr hab. inż.	0000-0002-6555-7657
7	Grzegorz Kudra	dr hab. inż.	0000-0003-0209-4664
8	Paweł Olejnik	dr hab. inż.	0000-0002-3310-0951
9	Artur Gutkowski	dr hab. inż.	0000-0002-2232-0166
10	Krzysztof Sobczak	dr hab. inż.	0000-0001-8994-6908
11	Radosław Mania	dr hab. inż.	0000-0003-4822-9149
12	Bogusław Pisarek	dr hab. inż.	0000-0002-4631-3155
13	Grzegorz Gumienny	dr hab. inż.	0000-0003-4671-3228
14	Ryszard Władysiak	dr hab. inż.	0000-0001-9341-4592
15	Witold Pawłowski	dr hab. inż.	0000-0002-1846-3615
16	Dawid Dudkowski	dr	0000-0002-3171-2698

17	Piotr Brzeski	dr inż.	0000-0002-1611-4550
18	Wojciech Stachurski	dr inż.	0000-0003-3936-6846
19	Leszek Czechowski	dr inż.	0000-0002-4718-6215
20	Mariusz Urbaniak	dr inż.	0000-0003-1849-0960
21	Krzysztof Surmiński	dr inż.	0000-0002-2560-8405
22	Bartłomiej Zagrodny	dr	0000-0002-7819-9940
23	Marcin Łęcki	dr inż.	0000-0002-4289-9208
24	Łukasz Frącczak	dr inż.	0000-0003-0684-3271

3. Training demand

The doctoral traininig in the discipline of mechanical engineering prepares a highly qualified specialist to work in industry, research units, R&D units and at technological universities. The educational aim of this programme is to introduce gradually the applicant into research works. Within the doctoral school, candidates broaden considerably their general and specialist knowledge, which allows them to conduct individually investigations as well as research and engineering projects in the field of mechanical engineering. Doctoral candidates gather also didactic and organizational experience, establish scientific contacts through participation in trainings, lectures, conferences and seminars. With the extended scope of knowledge and skills gained, doctoral candidates are able to carry out research activities and projects and to implement novel solutions into industrial practice.

4. Detailed entry requirements

According to the legal regulations in force, the formal requirement to be fulfilled by a candidate is to be a graduate of the second cycle studies and to have a scientific title of Master of Science or to be a beneficiary of the Diamond Grant within the Ministry for Science and Higher Education programme. It is preferable to be a graduate of a technological university in widely understood mechanical engineering, which, however, does not exclude graduates of programmes of study related to mathematics, applied physics or information technology at technological universities or universities. A candidate should demonstrate a capability of individual work, acquisition and application of knowledge from various disciplines, and show predispositions for objective analysis and evaluation of the collected observations and results of investigations.

5. Teaching methods

Research trainings, lectures, tutorials, lab classes, projects, scientific seminars

6. Graduate’s profile

Graduate in Mechanical Engineering demonstrates extensive knowledge in fundamental and applied sciences related to mechanical engineering and acquired skills allowing for solving interdisciplinary problems. One is prepared to implement modern methods, technical solutions and technologies while designing mechanical systems. The graduate is able to use advanced analytical,

computational and experimental techniques in the field of mechanical engineering. He/she is prepared to participate in computer-aided projects. Graduates are capable of acquiring and widening their knowledge on the basis of literature in the range required during work and can analyze critically the solutions proposed, indicate crucial limitations of the issues being solved and solve creatively the problems involved. The graduate can apply the knowledge acquired to solve selected scientific and technical problems, plan and analyze the results of experimental investigations. The extended scope of knowledge and the skills acquired enable him/her to conduct research and project activities and implement novel solutions into industrial applications. On graduating from the doctoral school and having written a PhD dissertation, the candidate demonstrates broad specialist knowledge, an ability to participate in scientific cooperation with other centers in Poland and abroad. The graduate attends a series of trainings and participates in workshops devoted to self-presentation techniques, application for research grants, management and communication in a team, application of IT tools, patenting and implementation procedures. The graduate shows research skills indispensable in further scientific work as well as research and implementation activities. The potential labor market for the graduate covers technological universities, companies active in the field of construction and technology of machine building, designing, industrial technologies, as well as R&D departments and design offices in manufacturing companies. The technical solutions graduates arrive at individually can be employed in their own innovation and implementation start-ups or technical support companies.

7. Training plan

Semester 1									
No	Subcategory	Subject							ECTS
			L	T	L	P	S	Σ	
1	E	Entrepreneurship	15					15	1
1	CC1	Mathematical Methods of Mechanics	20					20	1
2	CC2	Numerical Methods in Mechanics			20			20	2
3	CC3	Advanced Manufacturing	12		8			20	1
Total								75	5
Semester 2									
No	Subcategory	Subject							ECTS
			L	T	L	P	S	Σ	
1	CC4	Mechanics of Solids and Structures	15			5		20	1
2	CC5	Metrology and Control in Mechanical Engineering	8		12			20	2
3	CC6	Fluid Mechanics	20					20	1
Total								60	4
TOTAL								**135**	**9**

<table>
<tr><td>Course code</td><td>CC1</td></tr>
<tr><td>Type and description</td><td>CC - core curriculum for mechanical engineering discipline</td></tr>
<tr><td>ECTS credit</td><td>1</td></tr>
<tr><td>Course name</td><td>Mathematical methods of mechanics</td></tr>
<tr><td>Course name in Polish</td><td>Matematyczne metody mechaniki</td></tr>
<tr><td>Language of instruction</td><td>English</td></tr>
<tr><td>Course level</td><td>8 PRK</td></tr>
<tr><td>Course coordinator</td><td>prof. dr hab. inż. Jan Awrejcewicz</td></tr>
<tr><td>Course instructors</td><td>dr. hab. inż. Grzegorz Kudra, prof. PŁ</td></tr>
<tr><td>Delivery methods and course duration</td><td>
<table>
<tr><th></th><th>Lecture</th><th>Tutorials</th><th>Laboratory</th><th>Project</th><th>Seminar</th><th>Other</th><th>Total of teaching hours during semester</th></tr>
<tr><td>Contact hours</td><td>20</td><td></td><td></td><td></td><td></td><td>0</td><td>20</td></tr>
<tr><td>E-learning</td><td>No</td><td>No</td><td>No</td><td>No</td><td>No</td><td>No</td><td></td></tr>
<tr><td>Assessment criteria (weightage)</td><td>1,00</td><td></td><td></td><td></td><td></td><td>0,00</td><td>1,00</td></tr>
</table>
</td></tr>
<tr><td>Course objective</td><td>1. To enable students to acquire knowledge in the field of mathematical methods of vibration analysis of mechanical systems
2. To enable students to acquire knowledge in the field of mathematical methods of modelling mechanical systems</td></tr>
<tr><td>Learning outcomes</td><td>After the course the PhD student can:
1. characterize and present by examples the selected problems of parametric vibrations occurring in mechanical systems – outcome W1.
2. characterize and present by examples the selected concepts and methods of mathematical analysis of dynamical systems (phase space, singular points, perturbation methods) – outcome W1
3. characterize and present by examples the selected methods of mathematical modelling of mechanical systems (dynamics in generalized coordinates, governing equations of motion of a rigid body about a fixed point) – outcome W1</td></tr>
<tr><td>Assessment methods</td><td>Outcomes 1- 3 - written test
Final grade consists of:
result of written test - 100%</td></tr>
<tr><td>Prerequisites</td><td>1. Knowledge in the field of linear algebra and mathematical analysis, integral and differential calculus, basics of analytical geometry, basics of statistics, basics of matrix algebra.
2. Systematic and theoretically founded general knowledge of mechanics of material systems.</td></tr>
<tr><td>Course content with delivery methods</td><td>LECTURE
1. Linear differential equations with periodic coefficients. Hill’s equation. Meissner’s and Mathieu’s equations.
2. Phase plane and phase space. Singular points.
3. Perturbation methods. Autonomous systems: the Krylov and Krylov-Bogolubov-Mitropolskiy method. Non-autonomous systems: oscillations near and away from resonance.
4. Dynamics in generalized coordinates. Lagrange’s equations.
5. Rigid body motion about a fixed point. The Euler-Poinsot equations.</td></tr>
<tr><td>Basic reference materials</td><td>1. Awrejcewicz J.: Classical Mechanics. Kinematics and Statics. Springer, 2012.
2. Awrejcewicz J.: Classical Mechanics. Dynamics. Springer, 2012.
3. Awrejcewicz J.: Ordinary Differential Equations. Springer, 2014.</td></tr>
</table>

	4. Awrejcewicz J., Koruba Z.: Classical Mechanics. Applied Mechanics and Mechatronics. Springer, 2012.
Other reference materials	Arnol'd V. I.: Mathematical methods of classical mechanics. Vol. 60. Springer Science & Business Media, 2013.
Average student workload outside classroom	10
Comments	
Last update	2019.04.08

<table>
<tr><td>Course code</td><td>CC2</td></tr>
<tr><td>Type and description</td><td></td></tr>
<tr><td>ECTS credit</td><td>2</td></tr>
<tr><td>Course name</td><td>Numerical Methods in Mechanics</td></tr>
<tr><td>Course name in Polish</td><td>Numeryczne metody mechaniki</td></tr>
<tr><td>Language of instruction</td><td>English</td></tr>
<tr><td>Course level</td><td>8 PRK</td></tr>
<tr><td>Course coordinator</td><td></td></tr>
<tr><td>Course instructors</td><td></td></tr>
<tr><td>Delivery methods and course duration</td><td>
<table>
<tr><th></th><th>Lecture</th><th>Tutorials</th><th>Laboratory</th><th>Project</th><th>Seminar</th><th>Other</th><th>Total of teaching hours during semester</th></tr>
<tr><td>Contact hours</td><td>0</td><td>0</td><td>20</td><td>0</td><td>0</td><td>0</td><td>20</td></tr>
<tr><td>E-learning</td><td>No</td><td>No</td><td>No</td><td>No</td><td>No</td><td>No</td><td></td></tr>
<tr><td>Assessment criteria (weightage)</td><td>0,00</td><td>0,00</td><td>1,00</td><td>0,00</td><td>0,00</td><td>0,00</td><td></td></tr>
</table>
</td></tr>
<tr><td>Course objective</td><td>1. Enabling students to gain knowledge about application of numerical methods to simulate the dynamics of mechanical systems.
2. Enabling students to learn how to apply in practice numerical integration algorithms for dynamical systems of different types.</td></tr>
<tr><td>Learning outcomes</td><td>After finishing the course student can:
1. Apply different numerical integration algorithms – effects W1, U1
2. Choose appropriate integration method and parameters of integration algorithm depending on the type of dynamical system – effects W1, U1. Visualize the results of numerical integration make their physical interpretation – effects W1, U4</td></tr>
<tr><td>Assessment methods</td><td>Assessment methods:
effects W1, U1, U2, U4, K1, K3 - individual project
The final grade consists of:
Individual project evaluation - 80%
Activity during laboratory classes - 20%</td></tr>
<tr><td>Prerequisites</td><td></td></tr>
<tr><td>Course content with delivery methods</td><td>Laboratories:
1. Numerical integration of continuous systems. Creation and interpretation of time series and phase portraits.
2. Numerical integration of continuous systems. Creating Poincare maps and their interpretation.
3. Numerical integration of continuous systems. Generation of bifurcation diagrams and resonance plots and their interpretation.
4. Numerical integration of continuous systems with many degrees of freedom.
5. Numerical integration of continuous systems coupled by inertia matrix. Unbinding of differential equations.
6. Numerical integration of discontinuous systems including Coulomb friction. Non-continuous and continuous model.
7. Numerical integration of discontinuous systems with hard impact (restitution coefficient) and soft impact (various models).
8. Integration of a simple system using the finite element method (continuous beam).
9. The Galerkin method.
10. Discussion on individual projects.</td></tr>
</table>

Basic reference materials	1. Lecturer materials, 2. C. Conca, G. N. Galtica: Numerical Methods in Mechanics, Chapman & Hall, 1997 3. A. Greenbaum, T. P. Chartier: Numerical methods: design, application and computer implementation, Princeton University Press; .2012
Other reference materials	
Average student workload outside classroom	20h
Comments	
Last update	

<table>
<tr><td>Course code</td><td>CC3</td></tr>
<tr><td>Type and description</td><td>CC - Core Curriculum for the Mechanical Engineering Discipline</td></tr>
<tr><td>ECTS credit</td><td>1</td></tr>
<tr><td>Course name</td><td>Advanced Manufacturing</td></tr>
<tr><td>Course name in Polish</td><td>Zaawansowane Techniki Wytwarzania</td></tr>
<tr><td>Language of instruction</td><td>English</td></tr>
<tr><td>Course level</td><td>8 PRK</td></tr>
<tr><td>Course coordinator</td><td>Ph.D. D.Sc. Bogusław Pisarek, prof. LUT,</td></tr>
<tr><td>Course instructors</td><td>Ph.D. D.Sc. Bogusław Pisarek, prof. LUT, Ph.D. D.Sc inż. Ryszard Władysiak, prof. LUT, Ph.D. D.Sc Grzegorz Gumienny, prof. LUT, Ph.D. D.Sc.. Wojciech Stachurski</td></tr>
<tr><td>Delivery methods and course duration</td><td>
<table>
<tr><th></th><th>Lecture</th><th>Tutorials</th><th>Laboratory</th><th>Project</th><th>Seminar</th><th>Other</th><th>Total of teaching hours during semester</th></tr>
<tr><td>Contact hours</td><td>12</td><td></td><td>8</td><td></td><td></td><td></td><td>20</td></tr>
<tr><td>E-learning</td><td>No</td><td>No</td><td>No</td><td>No</td><td>No</td><td>No</td><td></td></tr>
<tr><td>Assessment criteria (weightage)</td><td>0,70</td><td></td><td>0,30</td><td></td><td></td><td></td><td></td></tr>
</table>
</td></tr>
<tr><td>Course objective</td><td>1. The aim of the course is to enable PhD students to get advanced knowledge about modern casting and machining processes.
2. The aim of the course is to familiarize PhD students with cutting tools and process condition monitoring.</td></tr>
<tr><td>Learning outcomes</td><td>A PhD student after completing the course can:
1. characterize processes that modify the physicochemical state of a liquid alloy – W1, U4, K3;
2. characterize advanced casting techniques and processes occurring during pouring moulds, solidification and crystallization of the alloy in the mould – W1, U4, K3;
3. evaluate and choose the right casting technique depending on the requirements of the product and production seriality – W1, U1, K1–K3;
4. characterize unconventional material removal processes – W1, U4, K1;
5. describe modern technologies used in machining processes – W1, U4, K1;
6. interpret and evaluate the influence of machining conditions on the surface integrity of the workpiece – W1, U1, U4, K1;
7. describe and apply measuring systems in the monitoring of the tool and cutting process – W1, U1, U4, K1.</td></tr>
<tr><td>Assessment methods</td><td>Verification methods of learning outcomes:
learning outcome 1–7 – written exam
learning outcome 1, 2, 6, 7 – reports from laboratory exercises
The final grade consists of:
the grade of the written exam – 70%
the grade of the laboratory exercise reports – 30%</td></tr>
<tr><td>Prerequisites</td><td></td></tr>
<tr><td>Course content with delivery methods</td><td>LECTURE
1. Advanced techniques of feeding castings and liquid alloys treatments.
2. Manufacturing castings with directional and monocrystalline structure; cast composites; pressing in a liquid state; casting in semi-solid state; 3D printing of moulds, 3D printing of metal parts of machines and devices.
3. Application of computer techniques in advanced foundry processes.
4. Unconventional material removal processes: erosion machining, concentrated energy</td></tr>
</table>

	beam machining, hybrid machining. 5. Machining of difficult-to-cut materials. Machining of hard and hardened materials. 6. High speed machining (HSM). High performance machining (HPM). 7. Ultraprecision machining (UPM). Micromachining and nanomachining. 8. Machining with modular, multi-task and mechatronic tools. 9. Unconventional methods of coolant (cutting fluid) supply in the machining processes: dry machining, minimum quantity lubrication (MQL), cryogenic cooling. Unconventional coolants: vegetable oils, nanofluids. 10. Surface integrity in machining. Technological surface layer. Surface layer parameters. Surface texture (ST). 11. Tool and process condition monitoring. LABORATORY 1. In-mould spheroidization technique of cast iron. 2. Casting of aluminium metal matrix composites. 3. Monitoring of machining process condition – measurement of vibration signal, acoustic emission (AE) and cutting force. 4. Surface layer condition after machining – measurements of surface texture parameters.
Basic reference materials	1. Mahi Sahoo, Ph.D., Sudhari "Sam" Sahu, Ph.D: Principles of Metal Casting, Third Edition, 2014, Publisher: McGraw-Hill Education: New York, ISBN: 9780071789752. 2. Grzesik W., 2016. Advanced Machining Processes of Metallic Materials: Theory, Modelling and Applications. 2nd Edition. Elsevier. 3. Davim J.P. (ed.), 2010. Surface Integrity in Machining. Springer. 4. Teti R., Jemielniak K., O'Donnell G., Dornfeld D., 2010. Advanced monitoring of machining operations. CIRP Annals - Manufacturing Technology, vol. 59/2, pp. 717-739.
Other reference materials	1. Campbell, J.: Complete Casting Handbook, 2011. Published by Elsevier Ltd. 2. Groover, M.P., 2008. Automation, Production Systems, and Computer-Integrated Manufacturing. Prentice Hall Int. Edition, 2008. 3. Kruszyński B., 2001. Surface integrity in grinding. A Series of Monographs, The Technical University Press, Łódź, Poland. 4. Groover M.P., 2010. Fundamentals of Modern Manufacturing: Materials, Processes and Systems. 4th edition. John Wiley &Sons, Inc., USA.
Average student workload outside classroom	10h
Comments	
Last update	

<table>
<tr><td>Course code</td><td>CC4</td></tr>
<tr><td>Type and description</td><td>CC - Basic programme rules for Mechanical Engineering</td></tr>
<tr><td>ECTS credit</td><td>1</td></tr>
<tr><td>Course name</td><td>Mechanics of Solids and Structures</td></tr>
<tr><td>Course name in Polish</td><td>Mechanika Materiałów albo Mechanika Ciała Stałego i Konstrukcji</td></tr>
<tr><td>Language of instruction</td><td>English</td></tr>
<tr><td>Course level</td><td>8 PRK</td></tr>
<tr><td>Course coordinator</td><td>dr hab. inz. Radosław Mania</td></tr>
<tr><td>Course instructors</td><td></td></tr>
<tr><td>Delivery methods and course duration</td><td>
<table>
<tr><th></th><th>Lecture</th><th>Tutorials</th><th>Laboratory</th><th>Project</th><th>Seminar</th><th>Other</th><th>Total of teaching hours during semester</th></tr>
<tr><td>Contact hours</td><td>15</td><td></td><td></td><td>5</td><td></td><td>0</td><td>15</td></tr>
<tr><td>E-learning</td><td>No</td><td>No</td><td>No</td><td>No</td><td>No</td><td>No</td><td></td></tr>
<tr><td>Assessment criteria (weightage)</td><td>60,00</td><td></td><td></td><td>40</td><td></td><td>0,00</td><td></td></tr>
</table>
</td></tr>
<tr><td>Course objective</td><td>The main objective of this course is:
1. giving a good foundation for the development of solutions to a selected class of problems in mechanics of solids (materials).
2. to develop the ability to provide analytical and experimental methods of structural analysis.
3. to develop an understanding of the governing material models (composite materials, elastic-plastic theories).
4. Broadening of applied mechanics for theoretical formulations and developments, variational formulations, inventing in engineering and sciences with regard to real materials.</td></tr>
<tr><td>Learning outcomes</td><td>1. apply governing models for chosen materials - orthotropic, elastic-plastic materials, brittle, hybrid - W1, U1, K1
2. define composite material properties for engineering structures and calculate strains and stresses for given set of applied loads - U2, U3, K3
3. asses load carrying capacity of orthotropic members in the scope of strength and failure criteria - W2, U1, U2</td></tr>
<tr><td>Assessment methods</td><td>effect W1, U1, U2, U3, …. - final exam in writing
effect - presentation
effect W2,K1, K3 – project presentation
Final grades is determined as:
Writing exam result - 60%
Project presentation - 40%</td></tr>
<tr><td>Prerequisites</td><td></td></tr>
<tr><td>Course content with delivery methods</td><td>LECTURE
1. Hooke's law for 3D and 2D for anisotropic materials (especially orthotropic composite),
2. strength hypotheses and criteria of failure,
3. stress tensor, strain tensor, invariants.
4. analysis of the state of stress and deformation of orthotropic materials,
5. fatigue strength of metals and composites,
6. fundamentals of fracture mechanics, stress intensity coefficient, energy release coefficient, introduction of composites to failure.
7. geometric and physical non-linearities,
8. constitutive models for elastic-plastic materials, theories of plastic deformation and plastic</td></tr>
</table>

	flow.
Basic reference materials	1. Lecture presentations 2. Fung Y.C., Foundations of Solid Mechanics, Prentice-Hall, 1965, 3. Gibson R. F., Principles of Composite Material Mechanics. Boca Raton: CRC Press, 2007. 4. Lubliner J., Theory of Plasticity, Pearson Ed., 2006. 4. Sadd M.H., Elasticity Theory, Applications, and Numerics, Elsevier, 2014. 5. Schijve J., Fatigue of Structures and Materials, Springer, 2009.
Other reference materials	current papers and publications
Average student workload outside classroom	10h
Comments	
Last update	08.04.2019

<table>
<tr><td>Course code</td><td>CC5</td></tr>
<tr><td>Type and description</td><td>CC – core curriculum for mechanical engineering discipline</td></tr>
<tr><td>ECTS credit</td><td>2</td></tr>
<tr><td>Course name</td><td>Metrology and control in mechanical engineering</td></tr>
<tr><td>Course name in Polish</td><td>Metrologia i sterowanie w inżynierii mechanicznej</td></tr>
<tr><td>Language of instruction</td><td>English</td></tr>
<tr><td>Course level</td><td>8 PRK</td></tr>
<tr><td>Course coordinator</td><td>prof. nadzw. dr hab. inż. Paweł Olejnik</td></tr>
<tr><td>Course instructors</td><td>prof. nadzw. dr hab. inż. Paweł Olejnik
dr inż. Krzysztof Surmiński</td></tr>
<tr><td>Delivery methods and course duration</td><td>
<table>
<tr><th></th><th>Lecture</th><th>Tutorials</th><th>Laboratory</th><th>Project</th><th>Seminar</th><th>Other</th><th>Total of teaching hours during semester</th></tr>
<tr><td>Contact hours</td><td>8</td><td></td><td>12</td><td></td><td></td><td>0</td><td>20</td></tr>
<tr><td>E-learning</td><td>No</td><td>No</td><td>No</td><td>No</td><td>No</td><td>No</td><td></td></tr>
<tr><td>Assessment criteria (weightage)</td><td>40,00</td><td></td><td>60,00</td><td></td><td></td><td>0,00</td><td>100,00</td></tr>
</table>
</td></tr>
<tr><td>Course objective</td><td>1. Transfer of basic knowledge in the field of metrology and control in mechatronic systems.
2. Acquiring the ability to analyze and build measuring lines.
3. Acquiring skills in the field of open and closed automatic control systems.</td></tr>
<tr><td>Learning outcomes</td><td>After completing the course the PhD student is able to:
1. describe the theoretical basics and the principles of using sensors, measuring cards and actuators in mechanical engineering – effects W1, U1, U2;
2. assess the validity of the implementation of selected measuring lines in mechatronic systems – effects W1, U1;
3. interpret phenomena that accompany experimental measurement – effects W1, U2, K1;
4. analyze selected systems of digital control – effects W1, U1, K1.</td></tr>
<tr><td>Assessment methods</td><td>Effects 1-4 will be verified by a written test and a laboratory report.
The final note will consist of the following parts:
assessment from the written test – 40%,
attendance and assessment from the laboratory – 60%.</td></tr>
<tr><td>Prerequisites</td><td>Basics of mechatronics</td></tr>
<tr><td>Course content with delivery methods</td><td>LECTURE
1. Construction and parameters of modern measuring cards.
2. Types of A/C converters.
3. Aliasing and anti-aliasing filters.
4. Sources of interference of the measurement signal and the ways of their elimination.
5. Methods of control of water level in a one- and multi-tank systems.
6. Control of stepper motors in application to driving of a belt pulley.
7. Stabilization of angular displacements with the use of PID regulation.
LABORATORY
1. Angle measurement using a potentiometric transducer, differentiation of the measurement signal).
2. Acceleration measurement using a three-axis micromechanical accelerometer with voltage output.
3. Multi-channel temperature measurement using digital and analog sensors.
4. Control of water level in a two-tank system.
5. Precise control of rotational velocity of a belt pulley subject to disturbances.</td></tr>
</table>

	6. PID control of a gimbal driven by BLDC motors.
Basic reference materials	1. A. S. Morris, R. Langari: Measurement and Instrumentation. Theory and Application, Butterworth-Heinemann, 2012. 2. ni.com
Other reference materials	
Average student workload outside classroom	5 h
Comments	
Last update	

<table>
<tr><td>Course code</td><td>CC6</td></tr>
<tr><td>Type and description</td><td></td></tr>
<tr><td>ECTS credit</td><td>1</td></tr>
<tr><td>Course name</td><td>Fluid Mechanics</td></tr>
<tr><td>Course name in Polish</td><td>Mechanika Płynów</td></tr>
<tr><td>Language of instruction</td><td>English</td></tr>
<tr><td>Course level</td><td>8 PRK</td></tr>
<tr><td>Course coordinator</td><td>dr hab. inż. Krzysztof Sobczak</td></tr>
<tr><td>Course instructors</td><td>dr hab. inż. Krzysztof Sobczak</td></tr>
<tr><td>Delivery methods and course duration</td><td>
<table>
<tr><th></th><th>Lecture</th><th>Tutorials</th><th>Laboratory</th><th>Project</th><th>Seminar</th><th>Other</th><th>Total of teaching hours during semester</th></tr>
<tr><td>Contact hours</td><td>20</td><td></td><td></td><td></td><td></td><td>0</td><td>20</td></tr>
<tr><td>E-learning</td><td>No</td><td>No</td><td>No</td><td>No</td><td>No</td><td>No</td><td></td></tr>
<tr><td>Assessment criteria (weightage)</td><td>0,00</td><td></td><td></td><td></td><td></td><td>0,00</td><td></td></tr>
</table>
</td></tr>
<tr><td>Course objective</td><td>Course objective
1. The aim of the course is to enable PhD students to acquire knowledge in the field of advanced problems of fluid flows.</td></tr>
<tr><td>Learning outcomes</td><td>After completing the course a PhD student can:
1. formulate the principles and equations of fluid dynamics as well as analyse and solve them for selected flow cases – outcomes W1, K1
2. describe turbulent flows and distinguish their characteristic features in free shear and wall-bounded turbulent flows – outcomes W1, U2
3. determine parameters of model tests using the similarity theory and indicate measurement methods for flow problems – outcomes W1, U1
4. describe and interpret complex phenomena taking place in internal and external flows – outcomes W2, U2, U4, K1</td></tr>
<tr><td>Assessment methods</td><td>Assessment methods
outcomes 1, 2, 3, 4 - exam
outcome 4 - presentation of the analysis of the selected flow problem

The final grade consists of:
Exam grade - 75%
Presentation - 25%</td></tr>
<tr><td>Prerequisites</td><td>Basic knowledge of incompressible and compressible fluid mechanics and thermodynamics.</td></tr>
<tr><td>Course content with delivery methods</td><td>Course content with delivery methods
LECTURE
1. Principles and equations of fluid dynamics. Conservation (balance) equations of mass, momentum (angular momentum) and energy in integral and differential forms. Derivation of the Navier-Stokes equation. Analysis and solutions of the Navier-Stokes equation for selected flow cases.
2. Turbulent flows. General characteristics of turbulent flows. Free shear and wall-bounded turbulent flows. Laminar-turbulent transition. Transport equations in a turbulent flow. Solution and modeling of turbulent flows.
3. Similarity theory. Similarity in model flow studies. Geometric, kinematic and dynamic similarity. Nondimensionalization of the governing equations. The Π theorem. The basic dimensionless (criteria) numbers of fluid dynamics. Application of modeling and its</td></tr>
</table>

	limitations. 4. Selected methods of flow parameter measurement. Hot-wire, Laser Doppler Velocimetry (LDV), Particle Image Velocimetry (PIV), pressure transducers, flowmeters (electromagnetic, ultrasonic, Coriolis, etc.). 5. Selected problems of internal and external flows. Separation of the boundary layer. Control methods for boundary layers. Shock wave - boundary layer interaction. Propeller aerodynamics.
Basic reference materials	1. Yunus A. Cengel, John M. Cimbala. ”Fluid Mechanics: Fundamentals and Applications”, McGraw-Hill, 2nd edition, 2010. 2. Frank M. White, ”Fluid Mechanics”, McGraw-Hill, 7th edition, 2009. 3. Stephen B. Pope, “Turbulent flows”, Cambridge University Press, 2001. 4. Lecturer's materials.
Other reference materials	1. Bruce R. Munson, Theodore H. Okiishi, Wade W. Huebsch, Alric P. Rothmayer, ”Fundamentals of fluid mechanics”, John Wiley & Sons, 7th edition, 2013. 2. Peter A. Davidson, “Turbulence An Introduction for Scientists and Engineers”, Oxford University Press, 2nd edition, 2015. 3. Bengt Andersson, et. al., ”Computational Fluid Dynamics for Engineers”, Cambridge University Press, 2012.
Average student workload outside classroom	10 h
Comments	
Last update	

Załącznik nr 3
do Programu Kształcenia w ISD PŁ –
ścieżka kształcenia w dyscyplinie
Automatyka, elektronika i
elektrotechnika

TRAINING PROGRAM IN DISCIPLINE:
Control, Electronic and Electrical Engineering

1. Basic information

Domain: Engineering and Technology
Discipline: Control, Electronic and Electrical Engineering
Degree awarded: PhD in Control, Electronic and Electrical Engineering
Program Coordinator:
Name: prof. dr hab. inż. Stanisław Hałgas
Email: stanislaw.halgas@p.lodz.pl

2. Lecturers

No	Name and surname	Title/degree	Website/ORCID
1	Paulo di Barba	dr hab.	0000-0001-5293-1809
2	Andrzej Bartoszewicz	prof.	0000-0002-1271-8488
3	Sławomir Hausman	dr hab.	0000-0003-3891-4214
4	Andrzej Materka	prof.	0000-0003-0864-1518
5	Maciej Sibiński	prof. PŁ	0000-0002-9752-3400
6	Michał Strzelecki	prof.	0000-0001-9102-4929
7	Krzysztof Ślot	prof.	0000-0003-1228-0970
8	Wojciech Tylman	dr hab.	0000-0002-6084-469X
9	Irena Wasiak	prof. PŁ	0000-0002-5156-7117
10	Katarzyna Znajdek	dr	0000-0001-8631-7364
11	Andrzej Wędzik	dr	0000-0002-1742-0736
12	Tomasz Siewierski	dr	0000-0002-2367-9242
13	Łukasz Jopek	dr	0000-0003-0341-878X

3. Training demand

The development of knowledge-based economy in the field of new technologies such as electrical, electronic and control engineering raises the demand for high-class specialists, including Ph.D. in engineering and technical sciences, employed in higher education institutions, research and

development departments, manager consulting firms, as well as in small and medium-sized enterprises. Graduates are expected to have broadened and theoretically grounded basic knowledge in disciplines related to the area of research, to be familiar with new trends, and to be able to think in a creative, innovative way. The abilities to supervise a team, to establish priorities and manage competing deadlines for themselves and others are also important.

4. Detailed entry requirements

Doctoral candidates may qualify for admission if they have a master's degree in science or engineering, in particular in the following fields: electrical, electronic, computer, and control engineering. Candidates should demonstrate the ability to present and defend their research plans, to evaluate and comment on the work of others, to participate in discussions on technical and scientific issues, to organize their self-education, and to conduct self-directed research. They should be able to acquire and apply the knowledge of other disciplines.

5. Teaching methods

Lectures, classes, laboratories, projects, seminars.

6. Graduate's profile

A graduate has a detailed knowledge corresponding to their own area of scientific research in control, electronic and electrical engineering. A young scientist is prepared to manage their own research team. They are able to work on R&D managerial position, create new structures and independent businesses such as Spin off/out or Start up. A graduate has the ability to modify, evaluate and consult new solutions in terms of their efficiency, profitability and innovation. They are able to review scientific publications, draw conclusions, present and defend their own opinions. They have acquired basic teaching skills. A graduate pursues research ethos that promotes exceptional expertise as well as ethical responsibility in the quest for knowledge and the development, conservation and transfer of such knowledge. They are aware of their professional responsibilities to society and to the specific communities in which they work.

PhD in electrical, electronic and control engineering is highly employable and can find work in many areas, including research and development departments, universities, and the sector of small and medium-sized enterprises. Thanks to a comprehensive education a graduate can be a leader of design and creative teams. They can work in consulting companies, and in the state/local government sector (public sector agencies, local government).

7. Training plan

Semester 1									
No.	Abbreviation	Course name	L	T	L	P	S	Σ	ECTS
1	E	Entrepreneurship	15					15	1
2	CC1	Scientific Research Methodology in Control, Electronic and Electrical Engineering	5	10				15	1
Total								30	2
Semester 2									
No.	Abbreviation	Course name	L	T	L	P	S	Σ	ECTS
1	CC2	Signals and systems	3				12	15	1
Total								15	1
Semester 3									

No.	Abbreviation	Course name							ECTS
			L	T	L	P	S	Σ	
1	CC3	Modeling of Dynamical Systems – part 1	5		10			15	1
2	CC4	Statistics for Control, Electronic and Electrical Engineering - part 1	10			5		15	1
Total								30	2
Semester 4									
No.	Abbreviation	Course name							ECTS
			L	T	L	P	S	Σ	
1	CC5	Modeling of Dynamical Systems - part 2					15	15	1
2	CC6	Statistics for Control, Electronic and Electrical Engineering - part 2	5			10		15	1
Total								30	2
MEDIUM-TERM ASSESSMENT									
Semester 5									
No.	Abbreviation	Course name							ECTS
			L	T	L	P	S	Σ	
1	CC7	Modern numerical methods in optimization – part 1	4	4		7		15	1
Total								15	1
Semester 6									
No.	Abbreviation	Course name							ECTS
			L	T	L	P	S	Σ	
1	CC8	Modern numerical methods in optimization – part 2	4	4		7		15	1
Total								15	1
TOTAL								**135**	**9**

<table>
<tr><td>Course code</td><td>CC1</td></tr>
<tr><td>Type and description</td><td>CC - Core Curriculum in Control, Electronic and Electrical Engineering</td></tr>
<tr><td>ECTS credit</td><td>1</td></tr>
<tr><td>Course name</td><td>Scientific Research Methodology in Control, Electronic and Electrical Engineering</td></tr>
<tr><td>Course name in Polish</td><td>Metodyka badań naukowych w automatyce, elektronice i elektrotechnice</td></tr>
<tr><td>Language of instruction</td><td>English</td></tr>
<tr><td>Course level</td><td>8 PRK</td></tr>
<tr><td>Course coordinator</td><td>prof. dr hab. inż. Andrzej Bartoszewicz</td></tr>
<tr><td>Course instructors</td><td>prof. dr hab. inż. Andrzej Bartoszewicz</td></tr>
<tr><td>Delivery methods and course duration</td><td>
<table>
<tr><th></th><th>Lecture</th><th>Tutorials</th><th>Laboratory</th><th>Project</th><th>Seminar</th><th>Other</th><th>Total of teaching hours during semester</th></tr>
<tr><td>Contact hours</td><td>5</td><td>10</td><td></td><td></td><td></td><td></td><td>15</td></tr>
<tr><td>E-learning</td><td>No</td><td>No</td><td>No</td><td>No</td><td>No</td><td>No</td><td></td></tr>
<tr><td>Assessment criteria (weightage)</td><td>0,33</td><td>0,67</td><td></td><td></td><td></td><td></td><td></td></tr>
</table>
</td></tr>
<tr><td>Course objective</td><td>1. The aim of the course is to acquaint students with basic concepts related to scientific research in electrical, electronic and control engineering.
2. The secondary objective is to familiarize students with their PhD program organization.
3. The course also aims at developing skills necessary for performing effective research and publishing research results among professionals and general public.</td></tr>
<tr><td>Learning outcomes</td><td>1. Student knows and understands research methodology appropriate for electrical, electronic and control engineering - W1
2. Student knows and understands the principles of research results dissemination in conventional and open access environment -W1
3. Can disseminate research results among professionals and general public - U2, K3
4. Is prepared to critically asses his/her own contribution to the field of electrical, electronic and control engineering - U1, K1</td></tr>
<tr><td>Assessment methods</td><td>Outcomes 1-3 – oral presentation
Outcome 4 - homework.</td></tr>
<tr><td>Prerequisites</td><td></td></tr>
<tr><td>Course content with delivery methods</td><td>Course contents
LECTURE
1. Requirements imposed on the PhD candidates by the Law on Higher Education and Science (Ustawa 2.0) and current regulations of the Polish Ministry of Science and Higher Education.
2. Fundamentals of academic writing and good practices in preparing research publications, public presentations and PhD theses.
3. Dissemination of research results.
4. Brief introduction to bibliometric factors.

TUTORIALS
1. Introduction to practical aspects of determining and interpreting various bibliometric factors.
2. Introduction to the use of databases fundamental for electrical, electronic and control engineering.
3. Paradigms of academic writing in electrical, electronic and control engineering.
4. Selection of appropriate means for dissemination of results.</td></tr>
<tr><td>Basic reference</td><td>1. The Law on Higher Education and Science (Ustawa 2.0) and current regulations of</td></tr>
</table>

materials	the Polish Ministry of Science and Higher Education. 2. Van Emden J., Easteal J., Technical writing and speaking. An introduction, McGraw Hill, 1996.
Other reference materials	1. Selected internet sources. 2. Writing an Engineering Technical Report available at : https://www.monash.edu/rlo/ assignment-samples/engineering/eng-writing-technical-reports
Average student workload outside classroom	10h
Comments	
Last update	5.04.2019

<table>
<tr><td>Course code</td><td>CC2</td></tr>
<tr><td>Type and description</td><td>CC - Core Curriculum in Control, Electronic and Electrical Engineering</td></tr>
<tr><td>ECTS credit</td><td>1</td></tr>
<tr><td>Course name</td><td>Signals and Systems</td></tr>
<tr><td>Course name in Polish</td><td>Sygnały i systemy</td></tr>
<tr><td>Language of instruction</td><td>English</td></tr>
<tr><td>Course level</td><td>8 PRK</td></tr>
<tr><td>Course coordinator</td><td>prof. dr hab. inż. Andrzej Materka</td></tr>
<tr><td>Course instructors</td><td>prof. dr hab. inż. Andrzej Materka</td></tr>
<tr><td>Delivery methods and course duration</td><td>
<table>
<tr><th></th><th>Lecture</th><th>Tutorials</th><th>Laboratory</th><th>Project</th><th>Seminar</th><th>Activity</th><th>Total of teaching hours during semester</th></tr>
<tr><td>Contact hours</td><td>3</td><td></td><td></td><td></td><td>12</td><td>0</td><td>15</td></tr>
<tr><td>E-learning</td><td>No</td><td>No</td><td>No</td><td>No</td><td>No</td><td>No</td><td></td></tr>
<tr><td>Assessment criteria (weightage)</td><td></td><td></td><td></td><td></td><td>0,80</td><td>0,20</td><td></td></tr>
</table>
</td></tr>
<tr><td>Course objective</td><td>Aim of course
1. To acquire knowledge on methods of mathematical modelling of physical systems as abstract entities which process and generate signals carrying information.
2. To apply the acquired knowledge to planning a research project whose goal is to solve, in an original way, a non-trivial scientific problem defined by the student.
3. To prepare, deliver and discuss a presentation on the proposed problem solution in terms of the involved signals and systems analysis methodology.</td></tr>
<tr><td>Learning outcomes</td><td>On completing the course, PhD student will be able to:
1. characterize main kinds of mathematical models of physical systems, as well as signals which are generated and/or processed in them – W1, U2, U4;
2. describe theoretical basis of system and signal model selection for representation of a device/measurement setup relevant to student' field of study – U1, K1</td></tr>
<tr><td>Assessment methods</td><td>Methods of study effects verification
Effects W1, U1, U2, U4, K1: teacher assessment of student' presentation and activity in the class (attendance, discussion).
The final mark comprises of evaluation of
Multimedia presentation – 80%
Activity – 20%</td></tr>
<tr><td>Prerequisites</td><td></td></tr>
<tr><td>Course content with delivery methods</td><td>LECTURE and SEMINAR
1. Signals, their sources and properties. Signal spectrum. Need for signal processing. Classes of signals (analogue, discrete, digital, deterministic, periodic and aperiodic, random, stationary and non-stationary, noise).
2. Systems classification (static, dynamic, causal, non-causal, linear, nonlinear, time-invariant, time-varying, stable, unstable). Convolution. Impulse response and frequency response. Positive and negative feedback.
3.Measuring signal and system properties (checking linearity, analogue to digital converter, aliasing, spectrum analyser, filters).
4. Numerical methods for signal analysis and system simulation.</td></tr>
<tr><td>Basic reference materials</td><td>1. Tadeusiewicz M.: Signals and Systems, Technical University of Łódź Press, Łódź, 2004
2. Oppenheim A., Wilsky A., Nawab S., Signals and Systems, Pearson New International Edition, Harlow UK, 2014.</td></tr>
</table>

Other reference materials	
Average student workload outside classroom	10h
Comments	
Last update	1.04.2019

Course code	CC3
Type and description	CC - Core Curriculum in Control, Electronic and Electrical Engineering
ECTS credit	1
Course name	**Modeling of Dynamical Systems – part 1**
Course name in Polish	**Modelowanie systemów dynamicznych – część 1**
Language of instruction	English
Course level	8 PRK
Course coordinator	**prof. dr hab. inż. Andrzej Bartoszewicz**
Course instructors	**prof. dr hab. inż. Andrzej Bartoszewicz**
Delivery methods and course duration	

	Lecture	Tutorials	Laboratory	Project	Seminar	Other	Tot□l of teaching hours during semester
Contact hours	5		10				15
E-learning	No	No	No	No	No	No	
Assessment criteria (weightage)	0,33		0,67				

Course objective	1. The aim of the course is to acquaint students with basic concepts in modeling of dynamical systems. 2. The course aims at developing skills and knowledge needed for modeling of dynamical systems, in particular modeling the systems using computer simulation programs.
Learning outcomes	After completing the course the student: 1. knows and understands the principles of mathematical modeling of dynamical systems; - W1 2. can describe how differential and difference equations arise in modelling of electric, electronic and electromechanical systems; - U1 3. is able to derive mathematical models of electric, electronic and electromechanical systems based on fundamental physical relations, - U1 4. is prepared to critically asses obtained results of modeling and simulations - U1, K1.
Assessment methods	Outcomes 1, 2 – oral presentation Outcome 3, 4 – homework.
Prerequisites	Elementary physics, basics of ordinary differential equations, fundamentals of mechanical and electrical engineering.
Course content with delivery methods	LECTURE 1. Principles of mathematical modeling of dynamical systems. 2. Types of models, model simplification. 3. Application the Lagrange formalism for modeling electric, electronic and electromechanical systems. 4. Basics of simulation methodology, numerical errors, computer simulation tools. LABORATORY 1. Introduction to modeling and simulation of electromechanical dynamical systems. 2. Selection of appropriate means for modeling, simulation and dissemination of results.
Basic reference materials	1. P. P. J. van den Bosch, A. C. van der Klauw, Modeling, Identification and Simulation of Dynamical Systems, CRC Press.
Other reference	1. Selected internet sources.

materials	
Average student workload outside classroom	10h
Comments	
Last update	6.04.2019

<table>
<tr><td>Course code</td><td>CC4</td></tr>
<tr><td>Type and description</td><td>CC - Core Curriculum in Control, Electronic and Electrical Engineering</td></tr>
<tr><td>ECTS credit</td><td>1</td></tr>
<tr><td>Course name</td><td>Statistics for Control, Electronic and Electrical Engineering – part 1</td></tr>
<tr><td>Course name in Polish</td><td>Statystyka dla automatyki, elektroniki i elektrotechniki – część 1</td></tr>
<tr><td>Language of instruction</td><td>English</td></tr>
<tr><td>Course level</td><td>8 PRK</td></tr>
<tr><td>Course coordinator</td><td>dr hab. inż. Wojciech Tylman</td></tr>
<tr><td>Course instructors</td><td>dr hab. inż. Wojciech Tylman</td></tr>
<tr><td>Delivery methods and course duration</td><td>
<table>
<tr><th></th><th>Lecture</th><th>Tutorials</th><th>Laboratory</th><th>Project</th><th>Seminar</th><th>Other</th><th>Total of teaching hours during semester</th></tr>
<tr><td>Contact hours</td><td>10</td><td></td><td></td><td>5</td><td></td><td></td><td>15</td></tr>
<tr><td>E-learning</td><td>No</td><td>No</td><td>No</td><td>No</td><td>No</td><td>No</td><td></td></tr>
<tr><td>Assessment criteria (weightage)</td><td>0</td><td></td><td></td><td>1,00</td><td></td><td></td><td></td></tr>
</table>
</td></tr>
<tr><td>Course objective</td><td>1. To make student acquainted with basic concepts and tools of descriptive statistics,
2. To make student acquainted with basic concepts and tools of statistical inference,
3. To make students acquainted with distributions commonly used in statistical inference,
4. To make students conscious of problems, errors and pitfalls associated with statistic.</td></tr>
<tr><td>Learning outcomes</td><td>After completing the course the student:
1. can use descriptive statistics to summarise a sample - U1,
2. knows and understands distributions commonly used in statistics, their role and means of computation - W1,
3. can use statistical inference in parameter estimation, hypothesis testing, confidence interval computation - U1,
4. can analyse relations between two populations - U1,
5. can employ statistics in problems related to research discipline and critically analyse results reported by others - K1.</td></tr>
<tr><td>Assessment methods</td><td>1-5 Series of individual projects employing concepts presented during lecture.</td></tr>
<tr><td>Prerequisites</td><td>Basic knowledge of mathematics, including probability theory.</td></tr>
<tr><td>Course content with delivery methods</td><td>LECTURE
1. Origins and branches of statistics,
2. Collecting data for statistical purposes,
3. Measures used to describe data sets: central tendency, variability, shape,
4. Sampling distributions,
5. Normal and t-distribution,
6. Chi-squared distribution,
7. Statistical hypothesis tests,
8. Confidence intervals,
9. Model-selection tests,
10. Correlation and regression,
11. Independence tests.

PROJECT
1. Describe example data set through descriptive statistics,</td></tr>
</table>

	2. Using example data, compute parameters of a sampling distribution, 3. Based on the sampling distribution, construct hypothesis test and compute confidence intervals, 4. Determine statistical relationships between two example data sets.
Basic reference materials	1. William Navidi: Statistics for Engineers and Scientists, McGraw-Hill Education, 2014.
Other reference materials	1. Sarah Boslaugh: Statistics in a Nutshell, O'Reilly Media, 2012.
Average student workload outside classroom	10h
Comments	
Last update	6.04.2019

<table>
<tr><td>Course code</td><td>CC5</td></tr>
<tr><td>Type and description</td><td>CC - Core Curriculum in Control, Electronic and Electrical Engineering</td></tr>
<tr><td>ECTS credit</td><td>1</td></tr>
<tr><td>Course name</td><td>Modeling of Dynamical Systems – part 2</td></tr>
<tr><td>Course name in Polish</td><td>Modelowanie systemów dynamicznych – część 2</td></tr>
<tr><td>Language of instruction</td><td>English</td></tr>
<tr><td>Course level</td><td>8 PRK</td></tr>
<tr><td>Course coordinator</td><td>prof. dr hab. inż. Andrzej Bartoszewicz</td></tr>
<tr><td>Course instructors</td><td>prof. dr hab. inż. Andrzej Bartoszewicz</td></tr>
<tr><td>Delivery methods and course duration</td><td>
<table>
<tr><th></th><th>Lecture</th><th>Tutorials</th><th>Laboratory</th><th>Project</th><th>Seminar</th><th>Other</th><th>Tot□l of teaching hours during semester</th></tr>
<tr><td>Contact hours</td><td></td><td></td><td></td><td></td><td>15</td><td></td><td>15</td></tr>
<tr><td>E-learning</td><td>No</td><td>No</td><td>No</td><td>No</td><td>No</td><td>No</td><td></td></tr>
<tr><td>Assessment criteria (weightage)</td><td></td><td></td><td></td><td></td><td>1,00</td><td></td><td></td></tr>
</table>
</td></tr>
<tr><td>Course objective</td><td>1. The course aims at developing skills for modeling of dynamical systems, effectively perform simulations and critically evaluate their results.
2. The secondary aim of the course is to give students a practical grounding in dissemination of their ideas and results among peers and professionals.</td></tr>
<tr><td>Learning outcomes</td><td>After completing the course the student:
1. knows and understands the methodology of modeling and simulation, - W1
2. is able to choose a proper numerical solver and its parameters for effective simulation of a given problem, - U1
3. can disseminate research results among professionals and general public, - U2
4. is prepared to critically asses his/her own contribution to the field of modeling and simulation of electric, electronic and electromechanical, dynamical systems - U1, K1.</td></tr>
<tr><td>Assessment methods</td><td>Outcomes 1 – 4 – oral presentation</td></tr>
<tr><td>Prerequisites</td><td>Modeling of Dynamical Systems – part 1.</td></tr>
<tr><td>Course content with delivery methods</td><td>SEMINAR
1. Presentation of modeling and simulation results obtained by the students for selected electric, electronic and electromechanical systems.</td></tr>
<tr><td>Basic reference materials</td><td>1. P. P. J. van den Bosch, A. C. van der Klauw, Modeling, Identification and Simulation of Dynamical Systems, CRC Press.</td></tr>
<tr><td>Other reference materials</td><td>1. Selected internet sources.</td></tr>
<tr><td>Average student workload outside classroom</td><td>10h</td></tr>
<tr><td>Comments</td><td></td></tr>
<tr><td>Last update</td><td>6.04.2019</td></tr>
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<table>
<tr><td>Course code</td><td>ECCC_CC6</td></tr>
<tr><td>Type and description</td><td>CC - Core Curriculum in Control, Electronic and Electrical Engineering</td></tr>
<tr><td>ECTS credit</td><td>1</td></tr>
<tr><td>Course name</td><td>Statistics for Control, Electronic and Electrical Engineering – part 2</td></tr>
<tr><td>Course name in Polish</td><td>Statystyka dla automatyki, elektroniki i elektrotechniki – część 2</td></tr>
<tr><td>Language of instruction</td><td>English</td></tr>
<tr><td>Course level</td><td>8 PRK</td></tr>
<tr><td>Course coordinator</td><td>dr hab. inż. Wojciech Tylman</td></tr>
<tr><td>Course instructors</td><td>dr hab. inż. Wojciech Tylman</td></tr>
<tr><td>Delivery methods and course duration</td><td>
<table>
<tr><th></th><th>Lecture</th><th>Tutorials</th><th>Laboratory</th><th>Project</th><th>Seminar</th><th>Other</th><th>Total of teaching hours during semester</th></tr>
<tr><td>Contact hours</td><td>5</td><td></td><td></td><td>10</td><td></td><td></td><td>15</td></tr>
<tr><td>E-learning</td><td>No</td><td>No</td><td>No</td><td>No</td><td>No</td><td>No</td><td></td></tr>
<tr><td>Assessment criteria (weightage)</td><td>0,00</td><td></td><td></td><td>1,00</td><td></td><td></td><td></td></tr>
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</td></tr>
<tr><td>Course objective</td><td>1. To make student acquainted with selected advanced concepts and tools of statistical inference,
2. To make student acquainted with basic concepts of normative decision theory.</td></tr>
<tr><td>Learning outcomes</td><td>After completing the course the student:
1. can analyse relations between more than two populations - U1,
2. can perform non-parametric statistical analysis of data - U1,
3. knows and understands basics of normative decision theory - W1.</td></tr>
<tr><td>Assessment methods</td><td>1-5 Individual project employing concepts presented during lecture and in Statistics for Control, Electronic and Electrical Engineering – part 1 course.</td></tr>
<tr><td>Prerequisites</td><td>Knowledge of statistics as presented in Statistics for electrical, electronic and control engineering part 1 course.</td></tr>
<tr><td>Course content with delivery methods</td><td>LECTURE
1. Analysis of variance (ANOVA),
2. Rank statistics,
3. Basic concepts of normative decision theory.

PROJECT
1. Apply statistical methods to a real-life problem, connected with the research discipline.</td></tr>
<tr><td>Basic reference materials</td><td>1. William Navidi: Statistics for Engineers and Scientists, McGraw-Hill Education, 2014,
2. Martin Peterson: An Introduction to Decision Theory, Cambridge University Press, 2017</td></tr>
<tr><td>Other reference materials</td><td>1. Sarah Boslaugh: Statistics in a Nutshell, O'Reilly Media, 2012.</td></tr>
<tr><td>Average student workload outside classroom</td><td>10h</td></tr>
<tr><td>Comments</td><td></td></tr>
<tr><td>Last update</td><td>6.04.2019</td></tr>
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<table>
<tr><td>Course code</td><td>CC7</td></tr>
<tr><td>Type and description</td><td>CC - Core Curriculum in Control, Electronic and Electrical Engineering</td></tr>
<tr><td>ECTS credit</td><td>1</td></tr>
<tr><td>Course name</td><td>Modern numerical methods in optimization – part 1</td></tr>
<tr><td>Course name in Polish</td><td>Nowoczesne metody numeryczne w optymalizacji – część 1</td></tr>
<tr><td>Language of instruction</td><td>English</td></tr>
<tr><td>Course level</td><td>8 PRK</td></tr>
<tr><td>Course coordinator</td><td>dr hab. inż. Paolo Di Barba</td></tr>
<tr><td>Course instructors</td><td>dr hab. inż. Paolo Di Barba, dr hab. inż. Sławomir Hausman</td></tr>
<tr><td>Delivery methods and course duration</td><td>
<table>
<tr><th></th><th>Lecture</th><th>Tutorials</th><th>Laboratory</th><th>Project</th><th>Seminar</th><th>Other</th><th>Total of teaching hours during semester</th></tr>
<tr><td>Contact hours</td><td>4</td><td>4</td><td></td><td>7</td><td></td><td></td><td>15</td></tr>
<tr><td>E-learning</td><td>No</td><td>No</td><td>No</td><td>No</td><td>No</td><td>No</td><td></td></tr>
<tr><td>Assessment criteria (weightage)</td><td>0,26</td><td>0,26</td><td></td><td>0,48</td><td></td><td></td><td></td></tr>
</table>
</td></tr>
<tr><td>Course objective</td><td>The aim of the course is to ensure that the student is acquainted basic knowledge of modern optimization methods as a way to solve inverse problems arising in electromagnetics. Since the aim of engineering education is to solve problems in a numerical fashion, special effort will be devoted to strengthen the computational skills of the student.</td></tr>
<tr><td>Learning outcomes</td><td>After the completion of the course, the students should be able to:
1. formulate the given inverse problem as an optimization problem - U1;
2. select an appropriate optimization algorithm - U1;
3. code objective functions and constraints - U1;
4. assess and discuss results - U2.</td></tr>
<tr><td>Assessment methods</td><td>During lectures and tutorials, extensive use of audience response systems (like e.g. the VoxVote platform) for assessing proficiency progress of students via anonimous polls will be made.
Learning outcomes 1-4 – Written presentation of an individual project.</td></tr>
<tr><td>Prerequisites</td><td>Principles of electromagnetics (fields and circuits), basic knowledge of numerical methods, use of toolboxes like e.g. MatLab or SciLab.</td></tr>
<tr><td>Course content with delivery methods</td><td>LECTURE
1. Solving an inverse problem by minimizing an objective function
2. A challenge: minimizing without derivatives
3. Deterministic computing: Nelder-Mead simplex method
4. Powell’s conjugate-direction method
5. Evolutionary computing: evolution strategy
6. Genetic algorithm
7. Nature-inspired computing: particle-swarm optimization
8. Wind-driven optimization
9. Handling constraints. No free-lunch theroem
10. Trading multiple objecitves: Pareto-like optimization

TUTORIALS
1. Benchmark: optimal shape design of a MEMS actuator (direct problem)
2. Benchmark: optimal shape design of a MEMS actuator (inverse problem)</td></tr>
</table>

	PROJECT 1. Solution of the benchmark problem by means of deterministic computing 2. Solution of the benchmark problem by means of evolutionary computing 3. Solution of the benchmark problem by means of nature-inspired computing
Basic reference materials	1. P. Di Barba, A. Savini, S. Wiak: ”Field models in electricity and magnetism”, Springer, 2008 2. P. Di Barba, S. Wiak: ”MEMS: field models and optimal design”, Springer, in press.
Other reference materials	1. Lecture notes by P. Di Barba
Average student workload outside classroom	10h
Comments	
Last update	April 2019

<table>
<tr><td>Course code</td><td>ECCC_CC8</td></tr>
<tr><td>Type and description</td><td>CC - Core Curriculum in Control, Electronic and Electrical Engineering</td></tr>
<tr><td>ECTS credit</td><td>1</td></tr>
<tr><td>Course name</td><td>Modern numerical methods in optimization – part 2</td></tr>
<tr><td>Course name in Polish</td><td>Nowoczesne metody numeryczne w optymalizacji – część 2</td></tr>
<tr><td>Language of instruction</td><td>English</td></tr>
<tr><td>Course level</td><td>8 PRK</td></tr>
<tr><td>Course coordinator</td><td>dr hab. inż. Paolo Di Barba</td></tr>
<tr><td>Course instructors</td><td>dr hab. inż. Paolo Di Barba, dr hab. inż. Sławomir Hausman</td></tr>
<tr><td>Delivery methods and course duration</td><td>
<table>
<tr><th></th><th>Lecture</th><th>Tutorials</th><th>Laboratory</th><th>Project</th><th>Seminar</th><th>Other</th><th>Total of teaching hours during semester</th></tr>
<tr><td>Contact hours</td><td>4</td><td>4</td><td></td><td>7</td><td></td><td></td><td>15</td></tr>
<tr><td>E-learning</td><td>No</td><td>No</td><td>No</td><td>No</td><td>No</td><td>No</td><td></td></tr>
<tr><td>Assessment criteria (weightage)</td><td>0,26</td><td>0,26</td><td></td><td>0,48</td><td></td><td></td><td></td></tr>
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</td></tr>
<tr><td>Course objective</td><td>The aim of the course is to ensure that the student is acquainted with basic knowledge of regularization methods as a way to solve inverse problems arising in electromagnetics. Since the aim of engineering education is to solve problems in a numerical fashion, special effort will be devoted to strengthen the computational skills of the student.</td></tr>
<tr><td>Learning outcomes</td><td>After the completion of the course, the students should be able to:
1. formulate the given inverse problem as a regularization problem - W1;
2. select an appropriate regularization algorithm - U1;
3. code the input-output transfer function - U1;
4. assess and discuss results - U2.</td></tr>
<tr><td>Assessment methods</td><td>During lectures and tutorials, extensive use of audience response systems (like e.g. the VoxVote platform) for assessing proficiency progress of students via anonimous polls will be made.
Learning outcomes 1-4 – Written presentation of an individual project.</td></tr>
<tr><td>Prerequisites</td><td>Principles of electromagnetics (fields and circuits), basic knowledge of numerical methods, use of toolboxes like e.g. MatLab or SciLab, Modern numerical methods in optimization – part 1</td></tr>
<tr><td>Course content with delivery methods</td><td>LECTURE
1. Direct and inverse problems
2. Insidiousess of inverse problems: no, one, infinite solutions
3. Hadamard’s conditions of well-posedness
4. Solving an inverse problem via a rectangular system of algebraic equations
5. Least-squares in terms of normal equations
6. Least-squares in terms of QR factorizaion
7. Singular-value decomposition
8. Truncated singular values
9. Tikhonov’s regularization
10. L-curve locus of quasi-solutions

TUTORIALS
1. Benchmark: synthesis of a uniform magnetic field (direct problem)
2. Benchmark: synthesis of a uniform magnetic field (inverse problem)
PROJECT
1. Solution of the benchmark problem by means of least squares</td></tr>
</table>

	2. Solution of the benchmark problem by means of singular values 3. Solution of the benchmark problem by means of Tikhonov's quasi-solution
Basic reference materials	1. P. Di Barba, A. Savini, S. Wiak: "Field models in electricity and magnetism", Springer, 2008 2. P. Di Barba, S. Wiak: "MEMS: field models and optimal design", Springer, in press.
Other reference materials	1. Lecture notes by P. Di Barba
Average student workload outside classroom	10h
Comments	
Last update	April 2019

Załącznik nr 4
do Programu Kształcenia w ISD PŁ –
ścieżka kształcenia w dyscyplinie
Informatyka techniczna i
telekomunikacja

TRAINING PROGRAM IN DISCIPLINE: Telecommunication and Computer Science

1. Basic information

Domain: Engineering and Technology
Discipline: Telecommunication and computer science
Degree awarded: PhD in Telecommunication and computer science
Program Coordinator:
Name: DSc. Eng. Piotr M. Szczypiński
Email: piotr.szczypinski@p.lodz.pl

2. Lecturers

No	Name and surname	Title/degree	Website/ORCID
1	Andrzej Materka	prof. dr hab. inż.	0000-0003-0864-1518
2	Wojciech Tylman	dr hab. inż.	0000-0002-3896-4230
3	Piotr Lipiński	dr hab. inż.	0000-0002-8269-3802
4	Adam Wojciechowski	dr hab. inż.	0000-0003-3786-7225
5	Artur Klepaczko	dr hab. inż.	0000-0003-4045-5870
6	Piotr Szczypiński	dr hab. inż. prof. PŁ	0000-0002-9956-0862
7	Piotr Napieralski	dr hab. inż.	0000-0003-1427-7791
8	Krzysztof Ślot	prof. dr hab. inż.	0000-0003-1228-0970
9	Adam Pelikant	dr hab. inż. prof. PŁ	https://pl.wikipedia.org/wiki/Adam_Pelikant
10	Dorota Kamińska	dr inż.	0000-0002-3416-5554
11	Adam Niewiadomski	dr hab. inż. prof. PŁ	0000-0001-7346-5472
12	Agnieszka Wosiak	dr hab. inż.	0000-0001-6124-1236
13	Michał Morawski	dr inż.	0000-0002-8902-1259

3. Training demand

Development of a knowledge-based economy in new technologies in the discipline of Telecommunication and computer science raises the demand for high-class specialists, including

degree of doctor of technical sciences, employed in scientific institutions, research and development units, consulting and advisory boards, as well as in the small and medium sector companies. Doctoral studies prepare the most talented candidates to write and defend dissertations.

4. Detailed entry requirements

Completing the Master's Degree in technical sciences or exact sciences, in particular in the following fields of study: electrical engineering, electronics and telecommunications, automation and robotics, computer science or applied mathematics. Candidate should show the ability to self-education, organization of his or her own work, presentation, discussion and communication skills.

5. Teaching methods

Lectures, individual and group projects, laboratory sessions, seminars.

6. Graduate's profile

Person who obtained the degree of doctor in discipline Telecommunication and computer science.

7. Training plan

Semester 1									
No.	Abbreviation	Course name	L	T	L	P	S	Σ	ECTS
1	E	Entrepreneurship	15					15	1
2	CC1	Research methodology	3				12	15	1
3	CC2	Statistics	4			26		30	2
Total								30	4
Semester 2									
No.	Abbreviation	Course name	L	T	L	P	S	Σ	ECTS
1	CC3	Advanced data processing algorithms and structures				15		15	1
2	CC4	Advanced human-computer interaction methods				15		15	1
Total								15	2
Semester 3									
No.	Abbreviation	Course name	L	T	L	P	S	Σ	ECTS
1	CC5	Computational intelligence 1			15			15	1
2	CC6	General-purpose computing on graphics processing units				15		15	1
Total								30	2
Semester 4									
No.	Abbreviation	Course name	L	T	L	P	S	Σ	ECTS
1	CC7	Computational intelligence 2				15		15	1
Total								15	1
TOTAL								**135**	**9**

<table>
<tr><td>Course code</td><td>CC1</td></tr>
<tr><td>Type and description</td><td>TCS core curriculum</td></tr>
<tr><td>ECTS credit</td><td>1</td></tr>
<tr><td>Course name</td><td>Research methodology</td></tr>
<tr><td>Course name in Polish</td><td>Metodyka pracy naukowej</td></tr>
<tr><td>Language of instruction</td><td>English</td></tr>
<tr><td>Course level</td><td>8 PRK</td></tr>
<tr><td>Course coordinator</td><td>prof. dr hab. inż Andrzej Materka</td></tr>
<tr><td>Course instructors</td><td>prof. dr hab. inż Andrzej Materka</td></tr>
<tr><td>Delivery methods and course duration</td><td>
<table>
<tr><th></th><th>Lecture</th><th>Tutorials</th><th>Laboratory</th><th>Project</th><th>Seminar</th><th>Other</th><th>Total of teaching hours during semester</th></tr>
<tr><td>Contact hours</td><td>3</td><td></td><td></td><td></td><td>12</td><td></td><td>15</td></tr>
<tr><td>E-learning</td><td>No</td><td>No</td><td>No</td><td>No</td><td>No</td><td>No</td><td></td></tr>
<tr><td>Assessment criteria (weightage)</td><td>20%</td><td></td><td></td><td></td><td>80%</td><td></td><td></td></tr>
</table>
</td></tr>
<tr><td>Course objective</td><td>Understanding the nature of scientific research and acquiring the ability to apply research methods.</td></tr>
<tr><td>Learning outcomes</td><td>1) Knowledge on the principles of methodology for conducting research and scientific projects.
2) Ability to acquire information from various sources, their integration, interpretation and critical evaluation, as well as concluding and formulating opinions, in particular when formulating and solving tasks related to modeling and designing elements, systems and manufacturing process.
3) Ability to assess the suitability and the feasibility of new achievements in the field of materials, elements, design methods and manufacturing for the design and manufacture of electronic, telecommunications and information processing systems.
4) Ability to formulate and test hypotheses related to selected issues in the field.</td></tr>
<tr><td>Assessment methods</td><td>Evaluation of research work on a given topic, reports, presentations and activity during seminar</td></tr>
<tr><td>Prerequisites</td><td></td></tr>
<tr><td>Course content with delivery methods</td><td>Lecture and seminar
Discussion of selected issues:
1. Introduction to the methodology of scientific research
2. Science and scientific disciplines
3. Methods of acquiring knowledge
4. Research strategy, scientific method
5. Troubleshooting
6. Methods of conducting research
7. Planning a scientific experiment
8. Work in teams
9. Ethics of scientific research

Outside classroom:</td></tr>
</table>

	1. A critical review of the literature 2. The structure of a scientific article 3. Presentation of the research report
Basic reference materials	A. Materka, lecture notes available from http://amaterka.pl/dydaktyka K. L. Turabian, A Manual for Writers of Research Papers, Theses, and Dissertations, 7th edition, The University of Chicago Press, 2007
Other reference materials	Journal papers collected by the students
Average student work-load outside classroom	10 h
Comments	
Last update	

<table>
<tr><td>Course code</td><td>CC2</td></tr>
<tr><td>Type and description</td><td>TCS core curriculum</td></tr>
<tr><td>ECTS credit</td><td>1</td></tr>
<tr><td>Course name</td><td>Statistics</td></tr>
<tr><td>Course name in Polish</td><td>Statystyka</td></tr>
<tr><td>Language of instruction</td><td>English</td></tr>
<tr><td>Course level</td><td>8 PRK</td></tr>
<tr><td>Course coordinator</td><td>dr hab. inż. Wojciech Tylman</td></tr>
<tr><td>Course instructors</td><td>dr hab. inż. Wojciech Tylman</td></tr>
<tr><td>Delivery methods and course duration</td><td>
<table>
<tr><th></th><th>Lecture</th><th>Tutorials</th><th>Laboratory</th><th>Project</th><th>Seminar</th><th>Other</th><th>Total of teaching hours during semester</th></tr>
<tr><td>Contact hours</td><td>4</td><td></td><td></td><td>26</td><td></td><td></td><td>30</td></tr>
<tr><td>E-learning</td><td>No</td><td>No</td><td>No</td><td>No</td><td>No</td><td>No</td><td></td></tr>
<tr><td>Assessment criteria (weightage)</td><td>20%</td><td></td><td></td><td>80%</td><td></td><td></td><td></td></tr>
</table>
</td></tr>
<tr><td>Course objective</td><td>1. To make student acquainted with basic concepts and tools of descriptive statistics,
2. To make student acquainted with selected concepts and tools of statistical inference,
3. To make students acquainted with distributions commonly used in statistical inference,
4. To make students conscious of problems, errors and pitfalls associated with statistics.
5. To make student acquainted with basic concepts of normative decision theory.</td></tr>
<tr><td>Learning outcomes</td><td>1. Can use descriptive statistics to summarise a sample,
2. Knows and understands distributions commonly used in statistics, their role and means of computation,
3. Can use statistical inference in parameter estimation, hypothesis testing, confidence interval computation,
4. Can analyse relations between two populations,
5. Can employ statistics in problems related to research discipline and critically analyse results reported by others.
6. Can analyse relations between more than two populations,
7. Can perform non-parametric statistical analysis of data,
8. Knows and understands basics of normative decision theory.</td></tr>
<tr><td>Assessment methods</td><td>Series of individual projects employing concepts presented during course.</td></tr>
<tr><td>Prerequisites</td><td>Basic knowledge of mathematics, including probability theory.</td></tr>
<tr><td>Course content with delivery methods</td><td>LECTURE
1. Origins and branches of statistics,
2. Collecting data for statistical purposes,
3. Measures used to describe data sets: central tendency, variability, shape,
4. Sampling distributions,
5. Normal and t-distribution,
6. Chi-squared distribution,
7. Statistical hypothesis tests,
8. Confidence intervals,
9. Model-selection tests,</td></tr>
</table>

	10. Correlation and regression, 11. Independence tests. 12. Analysis of variance (ANOVA), 13. Rank statistics, 14. Basic concepts of normative decision theory. PROJECT 1. Describe example data set through descriptive statistics, 2. Using example data, compute parameters of a sampling distribution, 3. Based on the sampling distribution, construct hypothesis test and compute confidence intervals, 4. Determine statistical relationships between two example data sets. 5. Apply statistical methods to a real-life problem, connected with the research discipline.
Basic reference materials	1. William Navidi: Statistics for Engineers and Scientists, McGraw-Hill Education, 2014. 2. Sarah Boslaugh: Statistics in a Nutshell, O'Reilly Media, 2012. 3. Martin Peterson: An Introduction to Decision Theory, Cambridge University Press, 2017.
Other reference materials	
Average student workload outside classroom	20 h
Comments	
Last update	

<table>
<tr><td>Course code</td><td>CC3</td></tr>
<tr><td>Type and description</td><td>TCS core curriculum</td></tr>
<tr><td>ECTS credit</td><td>1</td></tr>
<tr><td>Course name</td><td>Advanced data processing algorithms and structures</td></tr>
<tr><td>Course name in Polish</td><td>Zaawansowane algorytmy i struktury przetwarzania danych</td></tr>
<tr><td>Language of instruction</td><td>English</td></tr>
<tr><td>Course level</td><td>8 PRK</td></tr>
<tr><td>Course coordinator</td><td>dr hab. inż. Piotr Lipiński</td></tr>
<tr><td>Course instructors</td><td>dr hab. inż. Piotr Lipiński</td></tr>
<tr><td>Delivery methods and course duration</td><td>
<table>
<tr><th></th><th>Lecture</th><th>Tutorials</th><th>Laboratory</th><th>Project</th><th>Seminar</th><th>Other</th><th>Total of teaching hours during semester</th></tr>
<tr><td>Contact hours</td><td></td><td></td><td></td><td>15</td><td></td><td></td><td>15</td></tr>
<tr><td>E-learning</td><td>No</td><td>No</td><td>No</td><td>No</td><td>No</td><td>No</td><td></td></tr>
<tr><td>Assessment criteria (weightage)</td><td></td><td></td><td></td><td>100%</td><td></td><td></td><td></td></tr>
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</td></tr>
<tr><td>Course objective</td><td>Understanding and ability to use data processing algorithms and structures</td></tr>
<tr><td>Learning outcomes</td><td>After completing the course the student should be able to:
1) analyze a complex problem related to data processing and data structures
2) apply methods of data processing and use appropriate data structures
3) design and evaluate advanced data processing algorithms</td></tr>
<tr><td>Assessment methods</td><td>Evaluation of the final project presentation or/and final project report</td></tr>
<tr><td>Prerequisites</td><td>Fundamentals of algorithms and data structures course</td></tr>
<tr><td>Course content with delivery methods</td><td>Project which involves: design, implementation and evaluation of given problem. The student must use appropriate algorithms and data structures.</td></tr>
<tr><td>Basic reference materials</td><td>Donald E. Knuth, The Art of Computer Programming Vol 1 - Vol 3</td></tr>
<tr><td>Other reference materials</td><td>Drozdek A.: Data Structures and Algorithms in C++, Second Edition, 2001 by Brooks/Cole
Horovitz E., Sahni S.: Fundamentals of Computer Algorithms, Computer Science Press, 1978
Sedgevick R.: Algorithms in C++, Addison-Wesley Publishing Company, 1992</td></tr>
<tr><td>Average student work-load outside classroom</td><td>10 h</td></tr>
<tr><td>Comments</td><td></td></tr>
<tr><td>Last update</td><td>20.04.2019</td></tr>
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<table>
<tr><td>Course code</td><td>CC4</td></tr>
<tr><td>Type and description</td><td>TCS core curriculum</td></tr>
<tr><td>ECTS credit</td><td>1</td></tr>
<tr><td>Course name</td><td>Advanced human-computer interaction methods</td></tr>
<tr><td>Course name in Polish</td><td>Zaawansowane metody wspomagania interakcji człowiek-komputer</td></tr>
<tr><td>Language of instruction</td><td>English</td></tr>
<tr><td>Course level</td><td>8 PRK</td></tr>
<tr><td>Course coordinator</td><td>dr hab. inż. Adam Wojciechowski</td></tr>
<tr><td>Course instructors</td><td>dr hab. inż. Adam Wojciechowski</td></tr>
<tr><td>Delivery methods and course duration</td><td>
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<tr><th></th><th>Lecture</th><th>Tutorials</th><th>Laboratory</th><th>Project</th><th>Seminar</th><th>Other</th><th>Total of teaching hours during semester</th></tr>
<tr><td>Contact hours</td><td>3</td><td></td><td></td><td>12</td><td></td><td></td><td>15</td></tr>
<tr><td>E-learning</td><td>No</td><td>No</td><td>No</td><td>No</td><td>No</td><td>No</td><td></td></tr>
<tr><td>Assessment criteria (weightage)</td><td></td><td></td><td></td><td>100%</td><td></td><td></td><td></td></tr>
</table>
</td></tr>
<tr><td>Course objective</td><td>Understanding and ability to use advanced human-computer interaction methods</td></tr>
<tr><td>Learning outcomes</td><td>Knowledge and ability to use and evaluate advanced, multi modal, intelligent human-computer interaction methods</td></tr>
<tr><td>Assessment methods</td><td>Evaluation of project</td></tr>
<tr><td>Prerequisites</td><td>Image processing and analysis, machine learning, fundamentals of mathematics</td></tr>
<tr><td>Course content with delivery methods</td><td>Lecture:
- challenges of human computer interaction
- research methods in human computer interaction
- computer vision methods in human-machine interfaces
- multi modal interfaces – signal processing, analysis and integration
- machine learning methods for human computer interaction
Project:
- designing, implementation and evaluation of selected human-machine interaction methods</td></tr>
<tr><td>Basic reference materials</td><td>1) Handbook of Human-Computer Interaction, M.G. Helander, T.K. Landauer, P.V. Prabhu, Elsevier, 2014
2) Research methods in Human-Computer Interaction, J. Lazar, J.H. Feng, H. Hochheiser, Elsevier, 2017
3) The oxford handbook of affective computing, R.A. Calvo, S. D’Mello, J Gratch, A. Kappas, Oxford 2015</td></tr>
<tr><td>Other reference materials</td><td>1) Learning OpenCV, G. Bradski, A. Kaehler, O’Reilly, 2008
2) Human-Computer Interaction: Development Process, A. Sears, J.A. Jacko, Taylor and Francis, 2017
3) Metody i techniki sztucznej inteligencji, L. Rutkowski, PWN 2019</td></tr>
<tr><td>Average student work-load outside classroom</td><td>10 h</td></tr>
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Comments	
Last update	

<table>
<tr><td>Course code</td><td>CC5</td></tr>
<tr><td>Type and description</td><td>TCS core curriculum</td></tr>
<tr><td>ECTS credit</td><td>1</td></tr>
<tr><td>Course name</td><td>Computational Intelligence 1</td></tr>
<tr><td>Course name in Polish</td><td>Inteligencja obliczeniowa 1</td></tr>
<tr><td>Language of instruction</td><td>English</td></tr>
<tr><td>Course level</td><td>8 PRK</td></tr>
<tr><td>Course coordinator</td><td>dr hab. inż. Artur Klepaczko</td></tr>
<tr><td>Course instructors</td><td>dr hab. inż. Artur Klepaczko, dr hab. inż. prof. PŁ Piotr Szczypiński</td></tr>
<tr><td>Delivery methods and course duration</td><td>
<table>
<tr><th></th><th>Lecture</th><th>Tutorials</th><th>Laboratory</th><th>Project</th><th>Seminar</th><th>Other</th><th>Total of teaching hours during semester</th></tr>
<tr><td>Contact hours</td><td></td><td></td><td>15</td><td></td><td></td><td></td><td>15</td></tr>
<tr><td>E-learning</td><td>No</td><td>No</td><td>No</td><td>No</td><td>No</td><td>No</td><td></td></tr>
<tr><td>Assessment criteria (weightage)</td><td></td><td></td><td>100%</td><td></td><td></td><td></td><td></td></tr>
</table>
</td></tr>
<tr><td>Course objective</td><td>The objective of the course is to learn practical aspects of using machine learning algorithms and data mining methods applied to common engineering problems.</td></tr>
<tr><td>Learning outcomes</td><td>Development trends and research methodology in computational intelligence (W1)
Ability to use knowledge, apply methods of computational intelligence (U1)
Critical assessment of results produced by the computational intelligence algorithms, validation and verification of outcomes (K1)</td></tr>
<tr><td>Assessment methods</td><td>Upon completion of the laboratory tasks, students will deliver oral presentation reporting the obtained results. The presentation will be assessed based on completeness (40%), correctness (30%), visual quality of the presentation (15%) and clarity of communication (15%).</td></tr>
<tr><td>Prerequisites</td><td>Fundamentals of statistics and probability theory. Knowledge of Python language or ability to learn it fast independently.</td></tr>
<tr><td>Course content with delivery methods</td><td>The course covers the following computational intelligence algorithm:
1) Linear regression classifier
2) Support vector machine
3) Multi-layer Perceptron networks
4) Convolutional neural networks
5) Data modeling using non-linear regression methods
6) Forecasting future values of periodical signals with seasonal trends
The detailed problems will be explained in the laboratory instructions delivered to students during the laboratory sessions.
Acceptance of the laboratory tasks is subject to preparation of the final report in the form of oral presentation presented during the last laboratory session.</td></tr>
<tr><td>Basic reference materials</td><td>Computer science journals devoted to artificial intelligence and machine learning, e.g.: Artificial Intelligence, Data & Knowledge Engineering, Expert Systems with Applications, Neural Networks, Neurocomputing, IEEE Trans. Pattern Analysis and Machine Intelligence, IEEE Trans. Systems, Man, and Cybernetics, IEEE Trans. Neural Networks.</td></tr>
<tr><td>Other reference materials</td><td>Documentation of the Scikit-learn, Prophet, PyTorch and keras libraries</td></tr>
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Average student work-load outside classroom	10 h
Comments	
Last update	2019.04.17

<table>
<tr><td>Course code</td><td>CC6</td></tr>
<tr><td>Type and description</td><td>TCS core curriculum</td></tr>
<tr><td>ECTS credit</td><td>1</td></tr>
<tr><td>Course name</td><td>General-purpose computing on graphics processing units</td></tr>
<tr><td>Course name in Polish</td><td>Obliczenia na procesorach graficznych</td></tr>
<tr><td>Language of instruction</td><td>English</td></tr>
<tr><td>Course level</td><td>8 PRK</td></tr>
<tr><td>Course coordinator</td><td>dr hab. inż. Piotr Napieralski</td></tr>
<tr><td>Course instructors</td><td>dr hab. inż. Piotr Napieralski</td></tr>
<tr><td>Delivery methods and course duration</td><td>
<table>
<tr><th></th><th>Lecture</th><th>Tutorials</th><th>Laboratory</th><th>Project</th><th>Seminar</th><th>Other</th><th>Total of teaching hours during semester</th></tr>
<tr><td>Contact hours</td><td></td><td></td><td></td><td>15</td><td></td><td></td><td>15</td></tr>
<tr><td>E-learning</td><td>No</td><td>No</td><td>No</td><td>No</td><td>No</td><td>No</td><td></td></tr>
<tr><td>Assessment criteria (weightage)</td><td></td><td></td><td></td><td>100%</td><td></td><td></td><td></td></tr>
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</td></tr>
<tr><td>Course objective</td><td>Understanding and ability to use general-purpose computing on graphics processing units</td></tr>
<tr><td>Learning outcomes</td><td>Knowledge and ability to use general-purpose computing on graphics processing units</td></tr>
<tr><td>Assessment methods</td><td>Evaluation of project</td></tr>
<tr><td>Prerequisites</td><td>Knowledge of C ++, Knowledge of data structures</td></tr>
<tr><td>Course content with delivery methods</td><td>In this course will be present varieties of ways how to build a powerful high-performance system. Each uses different hardware architecture and software application interface (API) to achieve fast and accurate computing. Using General-Purpose Processing Units (GPGPU) is a trend in computer science that uses the GPU to perform the computations rather than CPU. Students during the course will propose their own solution to the problem related to their research topics in terms of processing on graphic processors.</td></tr>
<tr><td>Basic reference materials</td><td>Hubert Nguyen, GPU Gems 3: Programming Techniques for High-Performance Graphics and General-Purpose Computation
Jason Sanders and Edward Kandrot, CUDA by Example: An Introduction to General-Purpose GPU Programming</td></tr>
<tr><td>Other reference materials</td><td>Shigeyoshi Tsutsui and Pierre Collet, Massively Parallel Evolutionary Computation on GPGPUs (Natural Computing Series)</td></tr>
<tr><td>Average student work-load outside classroom</td><td>10 h</td></tr>
<tr><td>Comments</td><td></td></tr>
<tr><td>Last update</td><td></td></tr>
</table>

<table>
<tr><td>Course code</td><td>CC7</td></tr>
<tr><td>Type and description</td><td>TCS core curriculum</td></tr>
<tr><td>ECTS credit</td><td>1</td></tr>
<tr><td>Course name</td><td>Computational Intelligence 2</td></tr>
<tr><td>Course name in Polish</td><td>Inteligencja obliczeniowa 2</td></tr>
<tr><td>Language of instruction</td><td>English</td></tr>
<tr><td>Course level</td><td>8 PRK</td></tr>
<tr><td>Course coordinator</td><td>Artur Klepaczko</td></tr>
<tr><td>Course instructors</td><td>Artur Klepaczko, Piotr Szczypiński</td></tr>
<tr><td>Delivery methods and course duration</td><td>
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<tr><th></th><th>Lecture</th><th>Tutorials</th><th>Laboratory</th><th>Project</th><th>Seminar</th><th>Other</th><th>Total of teaching hours during semester</th></tr>
<tr><td>Contact hours</td><td></td><td></td><td></td><td>15</td><td></td><td></td><td>15</td></tr>
<tr><td>E-learning</td><td>No</td><td>No</td><td>No</td><td>No</td><td>No</td><td>No</td><td></td></tr>
<tr><td>Assessment criteria (weightage)</td><td></td><td></td><td></td><td>100%</td><td></td><td></td><td></td></tr>
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</td></tr>
<tr><td>Course objective</td><td>The objective of the course is to learn how to apply the machine learning toolbox to a given real-life task and solve a computational problem identified therein.</td></tr>
<tr><td>Learning outcomes</td><td>Deep study of methods and tools in computational intelligence (W1)
Ability to apply methods of computational intelligence in scientific research (U1)
Critical assessment of results produced by the computational intelligence algorithms, validation and verification of outcomes (K1)</td></tr>
<tr><td>Assessment methods</td><td>Projects will promote a teamwork. Upon completion of the assigned tasks, students will deliver a written report in the form of a conference paper. The paper will be assessed based on completeness of the solution (30%), correctness of the adopted solution procedure (40%), quality and structure of the paper (15%) and clarity of communication (15%).</td></tr>
<tr><td>Prerequisites</td><td>Knowledge of machine learning theory and tools. Fundamentals of statistics and statistical methods for evaluation of measurement results. Completion of TCS_CC5 course.</td></tr>
<tr><td>Course content with delivery methods</td><td>The course consists in solving a real-life task that contains a computational problem solvable with the use of a machine learning-based approach. The solution toolbox may include, but is not limited to, algorithms and methods learned by students under TCS_CC5 course (linear and non-linear regression, support vector machines, deep neural networks). The project tasks will concern image and signal classification and data modeling problems, proposed either by the teacher or students.</td></tr>
<tr><td>Basic reference materials</td><td>Computer science journals devoted to artificial intelligence and machine learning, e.g.: Artificial Intelligence, Data & Knowledge Engineering, Expert Systems with Applications, Neural Networks, Neurocomputing, IEEE Trans. Pattern Analysis and Machine Intelligence, IEEE Trans. Systems, Man, and Cybernetics, IEEE Trans. Neural Networks.</td></tr>
<tr><td>Other reference materials</td><td>Documentation of the Scikit-learn, Prophet, PyTorch and Keras libraries</td></tr>
</table>

Average student work-load outside classroom	10 h
Comments	
Last update	17.04.2019

Załącznik nr 5
do Programu Kształcenia w ISD PŁ –
ścieżka kształcenia w dyscyplinie
Inżynieria lądowa i transport

TRAINING PROGRAM IN DISCIPLINE:
Civil engineering and Transport

1. Basic information

Domain: Engineering and Technology
Discipline: Civil Engineering and Transport
Degree awarded: PhD in Civil Engineering and Transport
Program Coordinator:
Name: dr hab. inż. Marcin Koniorczyk
Email: marcin.koniorczyk@p.lodz.pl

2. Lecturers

No	Name and surname	Title/degree	Website/ORCID
1	Jarosław Jędrysiak	Prof.	https://orcid.org/0000-0002-4217-9198
2	Dariusz Gawin	Prof.	https://orcid.org/0000-0002-8240-4425
3	Marek Lefik	Prof.	https://orcid.org/0000-0001-9296-6205
4	Marcin Kamiński	Prof.	https://orcid.org/0000-0002-8180-6991
5	Zdzisław Więckowski	Prof.	https://orcid.org/0000-0002-8207-9116
6	Marcin Koniorczyk	dr hab. inż.	https://orcid.org/0000-0002-6887-4324
7	Renata Kotynia	dr hab. inż.	https://orcid.org/0000-0002-7247-1229
8	Piotr Ostrowski	dr hab. inż.	https://orcid.org/0000-0002-3088-4607
9	Jacek Szafran	dr hab. inż.	https://orcid.org/0000-0002-6984-0193
10	Artur Wirowski	dr hab. inż.	https://orcid.org/0000-0001-5251-321X
11	Piotr Konca	dr	https://orcid.org/0000-0002-5415-5169
12	Michał Gołdyn	dr	https://orcid.org/0000-0002-7791-1940
13	Witold Grymin	dr	https://orcid.org/0000-0002-2012-6087
14	Paulina Świątkiewicz	mgr	https://orcid.org/0000-0003-0985-

			0792
15	Tomasz Waśniwski	dr	https://orcid.org/0000-0001-7303-4920

3. Training demand

The knowledge based society requires highly skilled workers in various branches of industry related to material engineering, construction design, building maintenance, sustainable development, high schools ranking among the top ones, higher education and research and development centres. According to thorough investigations civil engineers are commonly those with least unemployment rate among engineers from various technical disciplines. This is a consequence of both theoretical and practical training which is implemented and which is based on utmost scrutiny and high level analysis. Moreover, the research skills, trained in civil engineering courses, lead to the habit of checking all details and foreseeing possible opportunities which is believed to be indispensable in a modern economy, which is based on innovation. With such a profile of research and related skills PhD in civil engineering are valued as possible employees in areas that require comprehensive analytical skills. Last but not least there is some demand of employing new instructors and assistant professors at universities and colleges in Poland due to the fact of increasing generation gap that has been observed. Moreover, graduates with attitude towards interdisciplinary research will bring some new ideas and possible influence future research directions.

4. Detailed entry requirements

For PhD in civil engineering there are eligible graduates of civil engineering, mechanics, materials engineering or other related courses. The candidates are advised to get in touch with possible future supervisor and tutors and start cooperation prior to the admission procedure. Future candidates are advised to investigate topics related to seminars held in the discipline of civil engineering and transport at the Lodz University of Technology as well as the formal and informal research requirements demanded by research groups. The choice of preferable research group prior to entrance examination is warmly advised since not all existing branches of civil engineering are present at LUT.

5. Teaching methods

Teaching methods vary from course to course reflecting the teaching attitude towards civil engineering. These comprise, laboratory applying the up-to-date measuring techniques, presentations with details being presented on the board, seminars, projects and case study problem solving using modern software, development of numerical codes for solving various non-linear problems but also traditional board and chalk lectures are given. Very often a sort of mixed methods is employed. There are offered courses allowing for broadening of knowledge and developing skills from various fields of engineering: mechanics, materials engineering, materials chemistry, steel and concrete reinforced structures, etc. Level of the courses is based on the profile of candidates and so are the methods which would be chosen through the course.

6. Graduate’s profile

PhD graduate in civil engineering and transport knows and understands the worldwide scientific knowledge related to the area of PhD thesis and their implications for practical applications, especially

in the other branches of engineering. The graduate can perform through analysis and synthesis of scientific results in order to identify and solve research task with introduction of innovative solutions and observations. PhD graduate is equipped with the broad knowledge in the field of civil engineering concerning in particular the mechanics of microstructural materials, the multiphysics problems, thermo-mechanics, etc. One is able to recognize and analyse the problems, select and efficiently use the appropriate scientific tools. The graduate can plan her/his development and inspire others to participate in discussions, solving problems, also in international environment. The graduate is ready to start independent scientific research, undertake challenges both in science and society, putting emphasis on ethical aspects and social impact of undertaken tasks.

7. Training plan

Semester 1									
No.	Abbreviation	Course name	L	T	L	P	S	Σ	ECTS
1	E	Entrepreneurship	15					15	1
2	CC1	Physics of Building Materials I	10		5			15	1
3	CC2	Physics of Building Materials II	8		7			15	1
4	CC3	Reliability and Optimization in Civil Engineering I	7			8		15	1
5	CC4	Reliability and Optimization in Civil Engineering II	7			8		15	1
Total								75	5
Semester 2									
No.	Abbreviation	Course name	L	T	L	P	S	Σ	ECTS
1	CC5	Advanced mechanics of soils I	10			5		15	1
2	CC6	Advanced mechanics of soils II	10			5		15	1
Total								30	2
Semester 3									
No.	Abbreviation	Course name	L	T	L	P	S	Σ	ECTS
1	CC7	Computational methods in non-linear solid mechanics I			15			15	1
2	CC8	Computational methods in non-linear solid mechanics II				15		15	1
Total								30	2
TOTAL								**135**	**9**

<table>
<tr><td>Course code</td><td>CC1</td></tr>
<tr><td>Type and description</td><td></td></tr>
<tr><td>ECTS credit</td><td>1</td></tr>
<tr><td>Course name</td><td>Physics of Building Materials 1</td></tr>
<tr><td>Course name in Polish</td><td>Fizyka porowatych materiałów budowlanych 1</td></tr>
<tr><td>Language of instruction</td><td>English</td></tr>
<tr><td>Course level</td><td>8 PRK</td></tr>
<tr><td>Course coordinator</td><td>Dariusz Gawin</td></tr>
<tr><td>Course instructors</td><td>Dariusz Gawin, Marcin Koniorczyk, Witold Grymin</td></tr>
<tr><td>Delivery methods and course duration</td><td>
<table>
<tr><th></th><th>Lecture</th><th>Tutorials</th><th>Laboratory</th><th>Project</th><th>Seminar</th><th>Other</th><th>Total of teaching hours during semester</th></tr>
<tr><td>Contact hours</td><td>10</td><td>0</td><td>5</td><td>0</td><td>0</td><td>0</td><td>15</td></tr>
<tr><td>E-learning</td><td>No</td><td>No</td><td>No</td><td>No</td><td>No</td><td>No</td><td></td></tr>
<tr><td>Assessment criteria (weightage)</td><td></td><td></td><td>1,00</td><td></td><td></td><td></td><td></td></tr>
</table>
</td></tr>
<tr><td>Course objective</td><td>Aims of the course is:
1. to extend knowledge in the field of Porous Materials Physics,
2. to learn formulating mathematical models of coupled energy and mass and linear momentum transport phenomena,
3. to learn numerical methods for simulation of coupled heat and moisture transport problems.</td></tr>
<tr><td>Learning outcomes</td><td>After the course student:
1. knows and understands basics of Porous Materials Physics (W1),
2. knows and is able to formulate initial-boundary problems for analysis of coupled energy and mass and linear momentum transport (U1),
3. knows the physical origins of mutual couplings between energy and mass and linear momentum transport in porous media (W1),
4. can derive a weak form of the mathematical model of coupled energy and mass and linear momentum transport (U1),
5. can derive macroscopic balance equations of coupled energy and mass and linear momentum transport in porous materials (U1),
6. knows and can apply numerical methods and/or softwares to analysis of coupled heat and mass transport in deformable porous building materials (U1).
7. can present the obtained results (U2).</td></tr>
<tr><td>Assessment methods</td><td>Verification methods of learning outcomes:
effects no. 1-8: by worksheet project.

The final grade is composed of:
75% - project
25% - oral presentation of achieved solutions in project</td></tr>
<tr><td>Prerequisites</td><td></td></tr>
<tr><td>Course content with delivery methods</td><td>Basics of porous materials physics: microstructure, physics of transport phenomena, effective stress principle.
Mathematical models of coupled energy and mass and linear momentum transport.</td></tr>
</table>

	Strong and weak formulation of the energy/mass/linear momentum transport in porous media. Application of Finite Element and Finite Difference Methods for simulation of coupled energy and mass and linear momentum transport. Numerical analysis of coupled heat and mass transport in deformable porous building materials Examples of practical application.
Basic reference materials	1. Aitkins, P., de Paula, J., 2002. Aitkins' Physical Chemistry, Seventh Edition. Oxford University Press Inc., New York. 2. Gregg, S.J., Sing, K.S.W., 1982. Adsorption, Surface Area and Porosity. Academic Press, London. 3. Lewis, R.W., Schrefler, B.A., 1998. The Finite Element Method in the Static and Dynamic Deformation and Consolidation of Porous Media, 2nd edition. John Wiley & Sons, Chichester. 4. Gawin, D., 2000. Modelling of coupled hygro-thermal phenomena in building materials and building components (in Polish), Scientific Bulletin of Łódź Technical University No 853. Editions of Łódź Technical University, Łódź.
Other reference materials	
Average student workload outside classroom	10h
Comments	
Last update	

<table>
<tr><td>Course code</td><td>CC2</td></tr>
<tr><td>Type and description</td><td></td></tr>
<tr><td>ECTS credit</td><td>1</td></tr>
<tr><td>Course name</td><td>Physics of Building Materials 2</td></tr>
<tr><td>Course name in Polish</td><td>Fizyka porowatych materiałów budowlanych 2</td></tr>
<tr><td>Language of instruction</td><td>English</td></tr>
<tr><td>Course level</td><td>8 PRK</td></tr>
<tr><td>Course coordinator</td><td>Dariusz Gawin</td></tr>
<tr><td>Course instructors</td><td>Dariusz Gawin, Marcin Koniorczyk, Witold Grymin</td></tr>
<tr><td>Delivery methods and course duration</td><td>
<table>
<tr><th></th><th>Lecture</th><th>Tutorials</th><th>Laboratory</th><th>Project</th><th>Seminar</th><th>Other</th><th>Total of teaching hours during semester</th></tr>
<tr><td>Contact hours</td><td>8</td><td>0</td><td>7</td><td>0</td><td>0</td><td>0</td><td>15</td></tr>
<tr><td>E-learning</td><td>No</td><td>No</td><td>No</td><td>No</td><td>No</td><td>No</td><td></td></tr>
<tr><td>Assessment criteria (weightage)</td><td></td><td></td><td>1,00</td><td></td><td></td><td></td><td></td></tr>
</table>
</td></tr>
<tr><td>Course objective</td><td>Aims of the course is:
1. to extend knowledge in the field of durability of porous building materials,
2. to learn formulating coupled mathematical models of chemo-hygro-thermo-mechanical phenomena in porous building materials,
3. to learn numerical methods for simulation of coupled chemo-hygro-thermo-mechanical phenomena in porous materials.</td></tr>
<tr><td>Learning outcomes</td><td>After the course student:
1. knows and understands main degradation processes influencing building materials durability (W1),
2. knows and understands physical and chemical fundamentals of porous building materials durability (W1),
3. knows and understands basics of chemical thermodynamics and physico-chemistry for analysis of porous building materials durability (W1),
4. knows and is able to formulate initial-boundary problems for analysis of coupled chemo-hygro-thermo-mechanical phenomena in porous materials (U1),
5. knows the chemical and physical origins of mutual couplings between chemical processes and hygro-thermo-mechanical processes in porous materials (W1),
6. can derive a weak form of the mathematical model of coupled chemo-hygro-thermo-mechanical phenomena in porous materials (U1),
7. knows and can apply numerical methods and/or softwares to analysis of coupled chemo-hygro-thermo-mechanical phenomena in porous building materials (U1).
8. can present the obtained results (U2).</td></tr>
<tr><td>Assessment methods</td><td>Verification methods of learning outcomes:
effects no. 1-8: by worksheet project.

The final grade is composed of:
75% - project
25% - oral presentation of achieved solutions in project</td></tr>
<tr><td>Prerequisites</td><td></td></tr>
</table>

Course content with delivery methods	Basics of durability of porous building materials. Basics of Thermodynamics of degradation processes in porous materials. Mathematical models of coupled chemo-hygro-thermo-mechanical phenomena in porous materials. Application of Finite Element and Finite Difference Methods for simulation of coupled chemo-hygro-thermo-mechanical phenomena in porous materials. Numerical analysis of coupled chemo-hygro-thermo-mechanical phenomena in porous materials Examples of practical application.
Basic reference materials	1. Aitkins, P., de Paula, J., 2002. Aitkins' Physical Chemistry, Seventh Edition. Oxford University Press Inc., New York. 2. Lewis, R.W., Schrefler, B.A., 1998. The Finite Element Method in the Static and Dynamic Deformation and Consolidation of Porous Media, 2nd edition. John Wiley & Sons, Chichester. 3. Gawin, D., 2000. Modelling of coupled hygro-thermal phenomena in building materials and building components (in Polish), Scientific Bulletin of Łódź Technical University No 853. Editions of Łódź Technical University, Łódź. 4. Gawin, D., 2010, Procesy degradacji mikrostruktury kompozytów cementowych w wysokiej temperaturze, Seria Studia z Zakresu Inżynierii Nr. 69, stron 232, ISBN 978-83-89687-54-8, Wydawnictwo Komitetu Inżynierii Lądowej i Wodnej PAN, Warszawa. 5. Koniorczyk, M., 2013, Transport i krystalizacja soli w materiałach budowlanych, Zesz. Nauk. Politech. Łódz. Rozpr. Nauk. 2013, z.443, stron 166, Łódź
Other reference materials	
Average student workload outside classroom	10h
Comments	
Last update	

<table>
<tr><td>Course code</td><td>CC3</td></tr>
<tr><td>Type and description</td><td>CC 3 – program basis for Civil Engineering and Transportation</td></tr>
<tr><td>ECTS credit</td><td>1</td></tr>
<tr><td>Course name</td><td>Reliability and Optimization in Civil Engineering I</td></tr>
<tr><td>Course name in Polish</td><td>Niezawodność i Optymalizacja w Budownictwie I</td></tr>
<tr><td>Language of instruction</td><td>English</td></tr>
<tr><td>Course level</td><td>8 PRK</td></tr>
<tr><td>Course coordinator</td><td>Prof. dr hab. inż. Marcin Kamiński</td></tr>
<tr><td>Course instructors</td><td>Prof. dr hab. inż. Marcin Kamiński</td></tr>
<tr><td>Delivery methods and course duration</td><td>
<table>
<tr><th></th><th>Lecture</th><th>Tutorials</th><th>Laboratory</th><th>Project</th><th>Seminar</th><th>Other</th><th>Total of teaching hours during semester</th></tr>
<tr><td>Contact hours</td><td>7</td><td></td><td></td><td>8</td><td></td><td>0</td><td>15</td></tr>
<tr><td>E-learning</td><td>No</td><td>No</td><td>No</td><td>No</td><td>No</td><td>No</td><td></td></tr>
<tr><td>Assessment criteria (weightage)</td><td>0,50</td><td></td><td></td><td>0,50</td><td></td><td>0,00</td><td>1,00</td></tr>
</table>
</td></tr>
<tr><td>Course objective</td><td>1. The main goal of this course is to present the fundamental definitions, theorems and properties in mathematical statistics, probability theory, stochastic processes and to present their significance and applications in engineering and applied sciences. Mathematical statistics with its computational implementation will be shown and discussed with special attention to its probabilistic convergence and its significance in engineering catastrophies' evidence and decision making.
2. Further, a role of stochastic processes and, particularly, time series in engineering analysis will be explained and presented jointly with a review of their basic theoretical properties and definitions.
3. The next goal is short survey on the stochastic perturbation method and its application in elementary engineering problems.
4. The final goal is to demonstrate how to perform an efficient computational implementation of all these issues using the symbolic computer program and to make a satisfactory parametric visualization of the results.</td></tr>
<tr><td>Learning outcomes</td><td>The student should be able to:
1. identify basic statistics, probabilistic moments and coefficients for the given random variable (both discrete and continuous) (W1);
2. make computational implementation of the Monte-Carlo simulation and analytical derivation of these moments and coefficients for simple engineering problems with random parameters (K1);
3. calculate basic properties of the time series with random coefficients (W1);
4. derive probabilistic moments and coefficients for some transforms of the random quantities or time series using stochastic perturbation technique (W1);
5. propose an efficient solution method to the given engineering problem with random parameters (K1);
6. discuss the differences in-between analytical, statistical and perturbation-based probabilistic characteristics (U1);
7. identify the basic sources of numerical error coming from various probabilistic computational techniques (U1).</td></tr>
<tr><td>Assessment methods</td><td>A verification of the learning outcomes is dual - with the use of a project and, separately, the final oral test. The purpose of the project is to derive using (a) analytical symbolic calculus, (b) Monte-Carlo simulation and (c) stochastic perturbation technique the resulting probabilistic moments and coefficients for a given transform (polynomial, harmonic or exponential) of the initial random variable. This study is to be performed with respect to (a) an initial random fluctuations level, (b) the number of random trials in statistical method and (c) an order of the perturbation technique to verify probabilistic convergence or divergence</td></tr>
</table>

	of these methods. This part may be verified electronically using some on-line consulting scheme. The second part of the verification is made on the basis of the written test concerning the basic information provided during both the lecture and a project, may take place after positive verification of the project and may be finished with short discussion with the candidate. Assessment methods for particular learning outcomes: the effects no 1, 3, 4 are to be verified during the exam, while effects no 2, 5, 6, 7 during presentation and defence of the project. Final grade from this course is composed with the oral exam result in 50% and also 50% from a presentation and a defence of the project.
Prerequisites	The candidate should have basic information from mathematics and computer science to use any symbolic computing program for a development of mathematical operations and numerical visualization.
Course content with delivery methods	LECTURE will include the following issues: 1. fundamental definitions, theorems and properties in probability theory - expected value, standard deviation, variance, skewness, kurtosis, coefficient of varation, probability density function (for single and multiple variables), characteristics function and cumulative density function, correlation function and coefficient of correlation; 2. presentation of various probabilistic distributions and their basic characteristics as well as possible engineering applications; 3. fundamental definitions, theorems and properties in mathematical statistics - basic probabilistic characteristics (as above), random numbers generation and sampling (crude and stratified), statistical estimation and convergence of estimators, Central Limit Theorem and its consequencies; 4. significance and applications of statistics in engineering and applied sciences - statistical evidence of failures, experimental statistics on engineering parameters, statistical prognosis of durability for engineering structures and materials; 5. continuous and discrete, stationary and non-stationary stochastic processes, their definitions and properties, time series analysis; 6. basic principles of stochastic perturbation methods (of the first, second and general order), perturbation-based derivation of the engineering formulas including some random variables; 7. computational implementation of statistics, probability, time series and stochastic processes in symbolic computing environment; statistical and stochastic simulation as well as estimation in the computers' world; 8. a short survey on the other probabilistic methods like spectral analysis, Latin Hypercube Sampling, fuzzy sets and polynomial chaos analysis. OTHER FORMS The lectures are supported by the e-learning realized via email submission of the presentations and computer applications to the program MAPLE as well as usage of the Author's webpage {http://www.kmk.p.lodz.pl/pracownicy/kaminski/index.htm} connected with the on-line discussion on the projects.
Basic reference materials	[1] M. Fisz, Probability Theory and Mathematical Statistics (in Polish), PSP, Warsaw, 1969. [2] M. Kamiński, The Stochastic Perturbation Method for Computational Mechanics. Wiley, Chichester, 2013. [3] K. Sobczyk, B.F. Spencer, Random Fatigue: From Data to Theory. Academic Press, Boston, 1992.
Other reference materials	[1] K. Sobczyk, Statistical Dynamics Methods (in Polish). PSP, Warsaw, 1973. [2] K. Sobczyk, Stochastic Differential Equations. With Applications to Physics and Engineering. Kluwer Academic Publishers, Dordrecht, 1990 (Polish edition also).
Average student workload outside classroom	20 h
Comments	Not applicable
Last update	04.04.2019

<table>
<tr><td>Course code</td><td>CC4</td></tr>
<tr><td>Type and description</td><td>CC 4 – program basis for Civil Engineering and Transportation</td></tr>
<tr><td>ECTS credit</td><td>1</td></tr>
<tr><td>Course name</td><td>Reliability and Optimization in Civil Engineering II</td></tr>
<tr><td>Course name in Polish</td><td>Niezawodność i Optymalizacja w Budownictwie II</td></tr>
<tr><td>Language of instruction</td><td>English</td></tr>
<tr><td>Course level</td><td>8 PRK</td></tr>
<tr><td>Course coordinator</td><td>Prof. dr hab. inż. Marcin Kamiński</td></tr>
<tr><td>Course instructors</td><td>Prof. dr hab. inż. Marcin Kamiński</td></tr>
<tr><td>Delivery methods and course duration</td><td>
<table>
<tr><th></th><th>Lecture</th><th>Tutorials</th><th>Laboratory</th><th>Project</th><th>Seminar</th><th>Other</th><th>Total of teaching hours during semester</th></tr>
<tr><td>Contact hours</td><td>15</td><td></td><td></td><td>15</td><td></td><td>0</td><td>30</td></tr>
<tr><td>E-learning</td><td>No</td><td>No</td><td>No</td><td>No</td><td>No</td><td>No</td><td></td></tr>
<tr><td>Assessment criteria (weightage)</td><td>0,50</td><td></td><td></td><td>0,50</td><td></td><td>0,00</td><td>1,00</td></tr>
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</td></tr>
<tr><td>Course objective</td><td>1. The first objective of the course is presentation of the fundamental definitions, theorems and methods in reliability analysis of civil engineering structures according to various order theories and its application and importance in engineering.
2. The second objective is presentation of structural sensitivity problem and an overview of different theories and methods in this area.
3. The next objective is presentation of the basic definitions and theorems concerning structural optimization in both linear and nonlinear ranges including cost function, constraints as well as non-gradient and gradient approaches. Various numerical methods enabling for determination of an optimal solution in linear, quadratic and nonlinear programming problems are to be presented.
4. Finally, computational implementation for all the aforementioned methods and structural state functions in computer algebra program MAPLE will be presented including numerical visualization and parametric discussion of the results achieved.</td></tr>
<tr><td>Learning outcomes</td><td>PhD student will be able after this course:
1. to define the reliability index, to list its admissible numerical values and also to demonstrate the basic analytical formulas for simple civil engineering applications (W1);
2. to determine the reliability indices according to the first and the second order theories using Monte-Carlo simulation, semi-analytical method as well as due to higher order stochastic perturbation technique (W1);
3. to define sensitivity coefficient and to propose various methods of its determination in different engineering problems (W1);
4. to determine sensitivity coefficients with the use of analytical methods, central finite difference method, semi-analytical method as well as direct differentiation method (W1);
5. to list and to describe various optimization methods applied in civil engineering problems (W1);
6. to determine solutions of the optimization problems without and with constraints for engineeirng problems with deterministic design parameters (U1);
7. to solve stochastic optimization problems with reliability indices constraints (U2);
8. to propose efficient numerical methods for a solution of the given engineering problem including reliability, sensitivity and optimization and to discuss the differences resulting from various numerical methods in this context (K1);
9. to optimize structural mass of the steel structure accounting for stochastic corrosion process (U1).</td></tr>
<tr><td>Assessment methods</td><td>Double assessment method is foreseen for the learning outcomes from this course – using a project, and separately, by the oral exam. The main aim of the project is to solve some stochastic optimization problem based on reliability of some civil engineering structure and</td></tr>
</table>

	it will include assessment of (a) analytical symbolic calculus, (b) determination of the key design parameter for the given case study, (c) its randomization using Monte-Carlo, semi-analytical and stochastic perturbation methods, (d) optimization of the structure mass using the constraints defined using reliability indices in the selected limit functions. A verification of this part is completed in an electronic way, using on-line consultations. The second part consists of the oral exam verifying fundamental information presented during the lecture and contained in the project and can be completed after successful presentation of the project. Assessment methods for the particular learning outcomes: the outcomes no 1, 3, 5, 8, 9 will be verified during oral exam, while the outcomes no 2, 4, 6, 8, 9 will be verified during presentation and discussion of the project. A final grade from this course consists from oral exam grade (50%) as well as presentation and defence of the project (50%).
Prerequisites	PhD candidate for this course should have the knowledge concerning mathematical analysis (linear algebra, probability theory) as well as computer science (visualization techniques) necessary for computer algebra programing or higher level programming language as well as all fundamental information delivered at the first part of this course.
Course content with delivery methods	LECTURE discusses the following topics: 1. basic definitions, theorems and properties in reliability assessment – catastrophe probability, safety index, reliability index and discussion of the engineering codes selected statements also; 2. fatigue loads and effects in civil engineering structures, fundamental theories concerning material and structural fatigue failure; 3. presentation of the definition as well as various methods of structural sensitivity approximation, and also of numerical analysis of sensitivity coefficients of civil engineering structures in linear elastic range, in large irreversible deformations and for heat transfer and thermo-elastic processes; 4. basic definitions and theorems in single and multicriterial optimization, linear, quadratic and nonlinear optimization problems with examples programmed in computer algebra system MAPLE; 5. presentation of the basic non-gradient (deterministic and stochastic) as well as gradient methods including especially Newton, Newton-Raphson as well as Broyden-Fletcher-Goldfarb-Shanno (BFGS) techniques; 6. application of the Finite Element Method and its stochastic extension as well as computer algebra programs for reliability, sensitivity and optimization problems; 7. application of the optimization apparatus supported with reliability analysis for statistical prognosis of civil engineering materials and structures. OTHER FORMS The lectures are supported with the presentations and exemplary computer programs coded in MAPLE as well as with lecturer webpage {http://www.kmk.p.lodz.pl/pracownicy/kaminski/index.htm} including online consultation of the project progress and of other issues concerning this course.
Basic reference materials	[1] J. Murzewski, Niezawodność konstrukcji inżynierskich. Arkady, Warszawa, 1989. [2] W. Pogorzelski, Teoria systemów i metody optymalizacji. OWPW, Warszawa, 1996. [3] R.T. Haftka, Z. Guerdal, Elements of Structural Optimization. Springer, Amsterdam, 1992.
Other reference materials	[1] M. Sysło, N. Deo, J.S. Kowalik, Algorytmy optymalizacji dyskretnej z programami w języku PASCAL. PWN, Warszawa, 1999. [2] M. Kleiber, Handbook of Computational Solid Mechanics. Springer Verlag, Berlin-Heidelberg, 1998.
Average student workload outside classroom	20 h
Comments	Not applicable
Last update	04.04.2019

<table>
<tr><td>Course code</td><td>CC5</td></tr>
<tr><td>Type and description</td><td></td></tr>
<tr><td>ECTS credit</td><td>1</td></tr>
<tr><td>Course name</td><td>Advanced mechanics of soils I</td></tr>
<tr><td>Course name in Polish</td><td>Pogłębiony wykład mechaniki gruntów I</td></tr>
<tr><td>Language of instruction</td><td>English</td></tr>
<tr><td>Course level</td><td>8 PRK</td></tr>
<tr><td>Course coordinator</td><td>Marek Lefik</td></tr>
<tr><td>Course instructors</td><td>Marek Lefik, Marek Wojciechowski</td></tr>
<tr><td>Delivery methods and course duration</td><td>
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<tr><th></th><th>Lecture</th><th>Tutorials</th><th>Laboratory</th><th>Project</th><th>Seminar</th><th>Other</th><th>Total of teaching hours during semester</th></tr>
<tr><td>Contact hours</td><td>10</td><td></td><td></td><td>5</td><td></td><td>0</td><td>15</td></tr>
<tr><td>E-learning</td><td>No</td><td>No</td><td>No</td><td>No</td><td>No</td><td>No</td><td></td></tr>
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<tr><td>Course objective</td><td>The purpose of lectures is not only to describe the behaviour of the soil but also to show the various ways of its scientific idealization. The lecture will present experimental sources of knowledge about soils behaviour. Soil mechanics will be presented as a set of interpretations of these experiments within the adopted mathematical model of the soil.
The objective of the course is also a presentation of different analytical and numerical solution of physically nonlinear problems appearing in mechanics of soils.</td></tr>
<tr><td>Learning outcomes</td><td>Advanced knowledge of soils behaviour
Advanced knowledge of water saturated soils behaviour
Advanced knowledge of analitycal modelling of soils
Advanced knowledge of numerical modelling of soils</td></tr>
<tr><td>Assessment methods</td><td>Verification of the lecture's outcome by means of a written test. (50% of the final note)
Presentation of a solution of an engineering problem individually solved in frame of the project. (50% of the final note)</td></tr>
<tr><td>Prerequisites</td><td>Basics of theory of elasticity and plasticity of solids</td></tr>
<tr><td>Course content with delivery methods</td><td>Subjects of the lecture:
Soil as a three-phase material. Concept of stress in soils. Fundamental equations via volume averaging. Fundamental phenomenological information concerning constitutive behaviour of soils: oedometric test, in situ tests. Strength of soils: triaxial tests and shear tests. Review of constitutive models of soils: Coulomb-Mohr, Cam-Clay and its variations, Drucker-Prager, hypoplasticity. Analytical solutions. Numerical solutions strategies. Water in soils. Groundwater flow. Darcy’s law via asymptotic</td></tr>
</table>

	homogenisation. Flows in soils. Local stability and bearing capacity of soils. Solutions by lines of characteristics. Slope stability. Subject of the project: Individual, guided solution of one of the following problems and presentation of the results: 1. Bearing capacity of direct foundation – numerical solutions versus engineering approach. 2. Bearing capacity of direct foundation – various constitutive models. 3. Numerical solution of flow toward wells – various models of flow. 4. Slope stability – comparison of various numerical and analytical results.
Basic reference materials	Arnold Verruijt, SOIL MECHANICS, Delft University of Technology, 2001, 2004 Robert V. Whitman T. William Lambe, Soil Mechanics, Wiley, 2012
Other reference materials	D. Kolymbas, Elements of hypoplasticity. In Constitutive Modelling of Geomaterials, B. Cambou, C. Di Prisco (Eds), Revue Francaise de Geotechnique Karl Terzaghi, Theoretical Soil Mechanics, Print ISBN:9780471853053 |Online ISBN:9780470172766 |DOI:10.1002/9780470172766, Copyright © 1943 John Wiley & Sons, Inc.
Average student workload outside classroom	10 h
Comments	
Last update	

<table>
<tr><td>Course code</td><td>TCE_CC6</td></tr>
<tr><td>Type and description</td><td></td></tr>
<tr><td>ECTS credit</td><td>1</td></tr>
<tr><td>Course name</td><td>Advanced Mechanics of Soils II</td></tr>
<tr><td>Course name in Polish</td><td>Pogłębiony wykład mechaniki gruntów II</td></tr>
<tr><td>Language of instruction</td><td>English</td></tr>
<tr><td>Course level</td><td>8 PRK</td></tr>
<tr><td>Course coordinator</td><td></td></tr>
<tr><td>Course instructors</td><td></td></tr>
<tr><td>Delivery methods and course duration</td><td>
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<tr><th></th><th>Lecture</th><th>Tutorials</th><th>Laboratory</th><th>Project</th><th>Seminar</th><th>Other</th><th>Total of teaching hours during semester</th></tr>
<tr><td>Contact hours</td><td>10</td><td></td><td></td><td>5</td><td></td><td>0</td><td>15</td></tr>
<tr><td>E-learning</td><td>No</td><td>No</td><td>No</td><td>No</td><td>No</td><td>No</td><td></td></tr>
<tr><td>Assessment criteria (weightage)</td><td>0,5</td><td></td><td></td><td>0,5</td><td></td><td></td><td></td></tr>
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<tr><td>Course objective</td><td>The purpose of lectures is not only to describe the behaviour of the soil but also to show the various ways of its scientific idealization. The lecture will present experimental sources of knowledge about soils behaviour. Soil mechanics will be presented as a set of interpretations of these experiments within the adopted mathematical model of the soil.

The objective of the course is also a presentation of different analytical and numerical solution of physically nonlinear problems appearing in mechanics of soils.

In the second part of the Advanced Mechanics of Soils the particular attention will be focused on soil-solid interaction</td></tr>
<tr><td>Learning outcomes</td><td>Advanced knowledge about soils behaviour

Advanced knowledge about water saturated soils behaviour

Advanced knowledge about analytical modelling of soils

Advanced knowledge about numerical modelling of soils</td></tr>
<tr><td>Assessment methods</td><td>Verification of the lecture's outcome by means of a written test. (50% of the final note)

Presentation of a solution of an engineering problem presented in frame of the project. (50% of the final note)</td></tr>
<tr><td>Prerequisites</td><td>Basics of theory of elasticity and plasticity of solids

Advanced mechanics of soils I (it is a continuation of the former lecture)</td></tr>
<tr><td>Course content with delivery methods</td><td>Subjects of the lecture:

Unsaturated soils. Soil as a four-phase material.
Consolidation. Other rheological behaviours.
Soil-structure interaction: Winkler’s model, Pasternak two parameter model, Żemoczkin</td></tr>
</table>

	model, generalised model. Various techniques of soils strengthening. Geotextiles, deep soil mixing, group of piles. Dynamics of soils. Waves in soils. Rayleigh waves. Experimental dynamics of soils. Interpretation of dynamic experiment. Subject of the project: Individual, guided solution of one of the following problems and presentation of the results: 1. Consolidation – numerical solutions versus the analytical one. Engineering approach. 2. Various constitutive models of expansive soils. 3. Numerical solution of plate on Winkler, Pasternak or Żemoczkin soil. 4. Generalised (Kosecki's) method for pile modelling versus a numerical solution.
Basic reference materials	Arnold Verruijt, SOIL MECHANICS, Delft University of Technology, 2001, 2004 Arnold Verruijt, An Introduction to Soil Dynamics ISBN 978-94-007-3096-0, Springer, 2010
Other reference materials	Robert V. Whitman T. William Lambe, Soil Mechanics, Wiley, 2012 Karl Terzaghi, Theoretical Soil Mechanics, Print ISBN:9780471853053 |Online ISBN:9780470172766 |DOI:10.1002/9780470172766, Copyright © 1943 John Wiley & Sons, Inc.
Average student workload outside classroom	10 h
Comments	
Last update	

<table>
<tr><td>Course code</td><td>TCE_CC7</td></tr>
<tr><td>Type and description</td><td></td></tr>
<tr><td>ECTS credit</td><td>1</td></tr>
<tr><td>Course name</td><td>Computational methods in non-linear solid mechanics I</td></tr>
<tr><td>Course name in Polish</td><td>Podstawy metod obliczeniowych nieliniowej mechaniki ciała stałego I</td></tr>
<tr><td>Language of instruction</td><td>English</td></tr>
<tr><td>Course level</td><td>8 PRK</td></tr>
<tr><td>Course coordinator</td><td>Zdzisław Więckowski</td></tr>
<tr><td>Course instructors</td><td>Paulina Świątkiewicz</td></tr>
<tr><td>Delivery methods and course duration</td><td>
<table>
<tr><th></th><th>Lecture</th><th>Tutorials</th><th>Laboratory</th><th>Project</th><th>Seminar</th><th>Other</th><th>Total of teaching hours during semester</th></tr>
<tr><td>Contact hours</td><td>15</td><td></td><td></td><td></td><td></td><td>0</td><td>15</td></tr>
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</td></tr>
<tr><td>Course objective</td><td>To present current knowledge on computational methods of non-linear solid mechanics.</td></tr>
<tr><td>Learning outcomes</td><td>After completing the course, a student will be able to:
1. recognize and formulate the problems of non-linear mechanics (W1 P8S_EG, U1 P8S_UW, U4 P8S_UU);
2. understand the basic iterative procedures of solving non-linear problems (W1 P8S_EG, U1 P8S_UW, U4 P8S_UU);
3. understand the computational methods applied to problems of non-linear solid mechanics (W1 P8S_EG, U1 P8S_UW, U4 P8S_UU).</td></tr>
<tr><td>Assessment methods</td><td>written test</td></tr>
<tr><td>Prerequisites</td><td></td></tr>
<tr><td>Course content with delivery methods</td><td>LECTURE:
Variational formulation of non-linear solid mechanics problems: geometrical non-linearities, physical non-linearities: e.g. plasticity and frictional contact problems.
Basic and advanced procedures of solving non-linear problems.
Application of the finite element method and point-based methods to non-linear engineering problems</td></tr>
<tr><td>Basic reference materials</td><td>1. O. C. Zienkiewicz and R. L. Taylor, The Finite Element Method, volume I, McGraw-Hill, London, 5th edition, 2000.
2. O. C. Zienkiewicz and R. L. Taylor, The Finite Element Method, volume II. McGraw-Hill, London, 5th edition, 2000.
3. K-J. Bathe, Finite Element Procedures in Engineering Analysis, Prentice-Hall, Englewood Cliffs, 1982.
4. G. Dhatt and G. Touzot, The Finite Element Method Displayed, John Wiley & Sons, Chichester, 1984.
5. T. J. R. Hughes, The Finite Element Method: Linear Static and Dynamic Finite Element Analysis, Prentice-Hall International, Inc., New Jersey, 1987.</td></tr>
<tr><td>Other reference materials</td><td></td></tr>
<tr><td>Average student workload outside classroom</td><td>15 hours</td></tr>
<tr><td>Comments</td><td></td></tr>
<tr><td>Last update</td><td>5 April, 2019</td></tr>
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<table>
<tr><td>Course code</td><td>CC8</td></tr>
<tr><td>Type and description</td><td></td></tr>
<tr><td>ECTS credit</td><td>1</td></tr>
<tr><td>Course name</td><td>Computational methods in non-linear solid mechanics II</td></tr>
<tr><td>Course name in Polish</td><td>Podstawy metod obliczeniowych nieliniowej mechaniki ciała stałego II</td></tr>
<tr><td>Language of instruction</td><td>English</td></tr>
<tr><td>Course level</td><td>8 PRK</td></tr>
<tr><td>Course coordinator</td><td>Zdzisław Więckowski</td></tr>
<tr><td>Course instructors</td><td>Paulina Świątkiewicz</td></tr>
<tr><td>Delivery methods and course duration</td><td>
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<tr><th></th><th>Lecture</th><th>Tutorials</th><th>Laboratory</th><th>Project</th><th>Seminar</th><th>Other</th><th>Total of teaching hours during semester</th></tr>
<tr><td>Contact hours</td><td></td><td></td><td></td><td>15</td><td></td><td>0</td><td>15</td></tr>
<tr><td>E-learning</td><td>No</td><td>No</td><td>No</td><td>No</td><td>No</td><td>No</td><td></td></tr>
<tr><td>Assessment criteria (weightage)</td><td>0,00</td><td></td><td></td><td>1.00</td><td></td><td>0,00</td><td></td></tr>
</table>
</td></tr>
<tr><td>Course objective</td><td>To get some experiences in application of modern computational methods to engineering problems of non-linear solid mechanics.</td></tr>
<tr><td>Learning outcomes</td><td>After completing the course, a student will be able to:
1. recognize and formulate the problems of non-linear mechanics (W1 P8S_EG, U1 P8S_UW, U4 P8S_UU);
2. understand the basic iterative procedures of solving non-linear problems (W1 P8S_EG, U1 P8S_UW, U4 P8S_UU);
3. understand the computational methods applied to problems of non-linear solid mechanics (W1 P8S_EG, U1 P8S_UW, U4 P8S_UU).
4. use properly available computer software to solve selected problems of non-linear solid mechanics (W1 P8S_EG, U1 P8S_UW, U4 P8S_UU).</td></tr>
<tr><td>Assessment methods</td><td>evaluation of solutions of the problems dedicated individually to each student</td></tr>
<tr><td>Prerequisites</td><td>Computational methods in non-linear solid mechanics I (CC7)</td></tr>
<tr><td>Course content with delivery methods</td><td>PROJECT:
Solution of several non-linear engineering problems using the finite element method. The problems are related to the material presented during the course ``Computational methods in non-linear solid mechanics I"</td></tr>
<tr><td>Basic reference materials</td><td>1. O. C. Zienkiewicz and R. L. Taylor, The Finite Element Method, volume I, McGraw-Hill, London, 5th edition, 2000.
2. O. C. Zienkiewicz and R. L. Taylor, The Finite Element Method, volume II. McGraw-Hill, London, 5th edition, 2000.
3. K-J. Bathe, Finite Element Procedures in Engineering Analysis, Prentice-Hall, Englewood Cliffs, 1982.
4. G. Dhatt and G. Touzot, The Finite Element Method Displayed, John Wiley & Sons, Chichester, 1984.
5. T. J. R. Hughes, The Finite Element Method: Linear Static and Dynamic Finite Element Analysis, Prentice-Hall International, Inc., New Jersey, 1987.</td></tr>
<tr><td>Other reference materials</td><td></td></tr>
<tr><td>Average student workload outside classroom</td><td>10 hours</td></tr>
<tr><td>Comments</td><td></td></tr>
<tr><td>Last update</td><td>5 April, 2019</td></tr>
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Załącznik nr 6
do Programu Kształcenia w ISD PŁ –
ścieżka kształcenia w dyscyplinie
Architektura i urbanistyka

TRAINING PROGRAM IN DISCIPLINE: Architecture and Urban Planning

1. Basic information

Domain: Engineering and Technology
Discipline: Architecture and urban planning
Degree awarded: PhD in Architecture and urban planning
Program Coordinator:
Name: Prof. DSc. Eng. Marek Pabich
Email: marek.pabich@p.lodz.pl; marekpabich1@gmail.com

2. Lecturers

No	Name and surname	Title/degree	Website/ORCID
1	Borowczyk Joanna	dr inż.	0000-0002-9626-7687
2	Breszka-Jędrzejewska Krystyna	mgr	-
3	Ciarkowski Błażej	dr inż.	0000-0001-5661-3429
4	Glinkowska-Musiałek Agata	dr inż.	0000-0001-6194-5401
5	Hanzl Małgorzata	dr hab. inż.	0000-0003-2495-5867
6	Janiak Marek	prof. dr hab. inż.	
7	Janicka-Świerguła Katarzyna	dr inż.	0000-0002-4536-3679
8	Kępczyńska-Walczak Anetta	dr hab. inż. arch., prof. PŁ	0000-0003-4125-2012
9	Mikielewicz Renata	dr inż.	0000-0002-6891-4138
10	Olenderek Joanna	dr hab. inż. arch., prof. PŁ	0000-0003-3774-3986
11	Olenderek Maciej	dr inż.	0000-0001-6926-9735
12	Pabich Marek	prof. dr hab. inż.	0000-0003-2831-2826
13	Salm Jan	dr hab. inż. arch., prof. PŁ	0000-0002-4260-5580
14	Serafin Aleksander	dr inż.	0000-0001-6300-5229
15	Skrzypkowska Julia	mgr	-
16	Stelmach Bolesław	dr hab. inż. prof. WSPA	-
17	Walczak Bartosz	dr hab. inż., prof. PŁ	0000-0002-9429-9626

18	Wesołowski Jacek	dr hab. inż., prof. PŁ	-
19	Witkowski Włodzimierz	dr inż.	0000-0003-1952-1730
20	Zaguła Artur	dr hab. inż., prof. PŁ	0000-0002- 5617-9041

3. Training demand

The Institute of Architecture and Urban Planning, TUL is one of the main centers in the central part of Poland educating doctors of technical sciences in the discipline of urban planning and architecture. The doctoral school prepares for work in research units, research and development units, in universities - especially technical ones through the gradual introduction of a candidate for research work using the latest achievements and scientific results in the field of doctoral studies selected by the candidate. A graduate after obtaining a doctorate not only has extensive knowledge in the field of urban planning and architecture, but also has the ability to set, analyse and propose solutions to problems and their synthetic description. These features allow to flexibly adapt to work also in areas that go beyond the disciplines of architecture and urban planning.

4. Detailed entry requirements

The formal requirement for candidates are the completion of the master's studies in the field of architecture or another with a similar scope. In addition, the candidate should demonstrate the ability to work independently, the ability to acquire and apply knowledge from various fields, as well as demonstrate predispositions for objective analysis and evaluation of the collected observations and research results.

5. Teaching methods

Lectures, classes, laboratories, projects, scientific seminars, distance learning.

6. Graduate’s profile

The graduate of the Doctoral School of TUL is a fully-fledged researcher, freely using the current state of scientific knowledge in the discipline of architecture and urban planning. Developing his career, he improves practical and theoretical skills of an interdisciplinary character. During training, one acquires knowledge related to the most advanced technologies, trends and development trends under the supervision of lecturers from domestic and foreign centres, which can be used in individual research. The Doctoral School prepares young scientists for both own research and cooperation within research teams, implementation of new techniques and technologies used in the discipline of architecture and urban planning - as well as creating independent entities such as Spin off / out or Start-ups. In addition, graduates gain knowledge needed to work in organizations related to local and government administration, cultural institutions and activities in the area of creative industries.

Graduates can also modify, give opinions and consult new solutions within architecture and urban planning in terms of their efficiency, profitability and innovation - also in the wider context of sustainable development and can find employment in all industries related to architecture, urban planning, design and broadly defined culture. Doctoral holders in technical sciences are not only talented scientists, but also represent the most valuable and creative background - as the middle and senior management in the creative industries and business. The research group gives the opportunity to

create innovative technologies and solutions in leading research and development centres in the field of architecture and urban planning.

7. Training plan

Semester 1									
No.	Abbreviation	Course name	L	T	L	P	S	Σ	ECTS
1	E	Entrepreneurship	15					15	1
2	CC1	Conducting research in the field of architecture and urban planning I	30					30	2
Total								45	3
Semester 2									
No.	Abbreviation	Course name	L	T	L	P	S	Σ	ECTS
1	CC2	Conducting research in the field of architecture and urban planning II					30	30	2
Total								30	2
Semester 3									
No.	Abbreviation	Course name	L	T	L	P	S	Σ	ECTS
1	CC3	Conducting research in the field of architecture and urban planning III	30					30	2
Total								30	2
Semester 4									
1	CC4	Conducting research in the field of architecture and urban planning IV	30					30	2
								30	2
TOTAL								**135**	**9**

<table>
<tr><td>Course code</td><td>CC1</td></tr>
<tr><td>Type and description</td><td></td></tr>
<tr><td>ECTS credit</td><td>2</td></tr>
<tr><td>Course name</td><td>Conducting research in the field of architecture and urban planning I</td></tr>
<tr><td>Course name in Polish</td><td>Prowadzenie badań w dyscyplinie architektura i urbanistyka I</td></tr>
<tr><td>Language of instruction</td><td>English</td></tr>
<tr><td>Course level</td><td>8 PRK</td></tr>
<tr><td>Course coordinator</td><td>Dr hab. nt. Artur Zaguła</td></tr>
<tr><td>Course instructors</td><td>Dr hab. nt. Artur Zaguła, dr inż. arch. Błażej Ciarkowski</td></tr>
<tr><td>Delivery methods and course duration</td><td>
<table>
<tr><th></th><th>Lecture</th><th>Tutorials</th><th>Laboratory</th><th>Project</th><th>Seminar</th><th>Other</th><th>Total of teaching hours during semester</th></tr>
<tr><td>Contact hours</td><td>0</td><td></td><td></td><td></td><td></td><td>0</td><td>30</td></tr>
<tr><td>E-learning</td><td>No</td><td>No</td><td>No</td><td>No</td><td>No</td><td>No</td><td></td></tr>
<tr><td>Assessment criteria (weightage)</td><td>0,00</td><td></td><td></td><td></td><td></td><td>0,00</td><td></td></tr>
</table>
</td></tr>
<tr><td>Course objective</td><td>The aim of the course
1. The aim of the course is to prepare students for conducting scientific research in the discipline architecture and urban planning - creating footnotes and bibliography, the state of research, skilful selection of methodology.
2. The aim of the subject is also to develop the ability to critically read and understand written sources regarding contemporary architecture and urban planning.</td></tr>
<tr><td>Learning outcomes</td><td>A PhD student after completing the course is able to:
1. use different types of footnotes, create a bibliography and state of research, and select methodologies appropriate to the subject of research.
2. analyze the structure, research methodology and the content of scientific studies on contemporary architecture and urban planning.
3. critically approach and evaluate written sources regarding contemporary architecture and urban planning.
4. Formulate own conclusions regarding scientific studies in the field of contemporary architecture and urban planning.</td></tr>
<tr><td>Assessment methods</td><td>Verification methods of learning outcomes
effect 1 - presented written work
effects 2,3,4 - presentation and discussion
The final grade consists of:
The result of the written text - 60%
Presentation and discussion - 40%</td></tr>
<tr><td>Prerequisites</td><td>None</td></tr>
<tr><td>Course content with delivery methods</td><td>Seminar
At the first class, a list of reading material is passed to PhD students (each year selected individually with doctoral students). Next, during classes students prepare footnotes, bibliographies and become acquainted with the creation of the state of research and methodologies for conducting research in the discipline of architecture and urban planning. Readings are books and chapters in scientific or popular science books and scientific articles. During the seminars there is a discussion about the structure, research methodology and content of the papers. Doctoral students also present the assessment and their own conclusions resulting from the reading.</td></tr>
<tr><td>Basic reference materials</td><td>Determined each year individually with doctoral students.</td></tr>
<tr><td>Other reference materials</td><td></td></tr>
<tr><td>Average student workload outside classroom</td><td>30</td></tr>
</table>

Comments	
Last update	

<table>
<tr><td>Course code</td><td>CC2</td></tr>
<tr><td>Type and description</td><td></td></tr>
<tr><td>ECTS credit</td><td>2</td></tr>
<tr><td>Course name</td><td>Conducting research in the field of architecture and urban planning</td></tr>
<tr><td>Course name in Polish</td><td>Prowadzenie badań w dyscyplinie architektura i urbanistyka</td></tr>
<tr><td>Language of instruction</td><td>English</td></tr>
<tr><td>Course level</td><td>8 PRK</td></tr>
<tr><td>Course coordinator</td><td>dr hab. inż. arch. Anetta Kępczyńska-Walczak, prof. PŁ</td></tr>
<tr><td>Course instructors</td><td>dr hab. inż. arch. Anetta Kępczyńska-Walczak, prof. PŁ, dr inż. arch. Aleksander Serafin</td></tr>
<tr><td>Delivery methods and course duration</td><td>
<table>
<tr><th></th><th>Lecture</th><th>Tutorials</th><th>Laboratory</th><th>Project</th><th>Seminar</th><th>Other</th><th>Total of teaching hours during semester</th></tr>
<tr><td>Contact hours</td><td>0</td><td></td><td></td><td></td><td>30</td><td>0</td><td>30</td></tr>
<tr><td>E-learning</td><td>No</td><td>No</td><td>No</td><td>No</td><td>No</td><td>No</td><td></td></tr>
<tr><td>Assessment criteria (weightage)</td><td>0,00</td><td></td><td></td><td></td><td></td><td>0,00</td><td></td></tr>
</table>
</td></tr>
<tr><td>Course objective</td><td>1. Preparation for conducting scientific research in the discipline of architecture and urban planning
2. Acquisition of doctoral skills in the field of writing scientific texts, taking into account the specificity of the discipline architecture and urban planning.</td></tr>
<tr><td>Learning outcomes</td><td>After completing the course a PhD student is able to:
1) adapt the research method to specific scientific interests;
2) develop skills in the selection and evaluation of sources;
3) correctly apply footnotes in the scientific text and distinguish bibliographic styles;
4) plan the structure of the scientific text;
5) formulate own conclusions;
6) interpret the concept of intellectual property in the context of copyright;
7) prepare for a public performance.</td></tr>
<tr><td>Assessment methods</td><td>1) the essay;
2) the presentation;
3) participation in the discussion.
The final grade consists of:
- assessment of written work - 50%
- presentation and discussion - 50%</td></tr>
<tr><td>Prerequisites</td><td>None</td></tr>
<tr><td>Course content with delivery methods</td><td>The course starts with the introduction to the characteristics of doctoral dissertation, its elements and thesis. This part is based on case studies and summed up with discussion.
Each PhD student declares to read selected two or three lectures related to his own area of scientific interests. Subsequently, the PhD student prepares a multimedia presentation in which he reports to the group the acquired texts, then formulates theses, supports them with analyses and clearly articulates his own conclusions. After the presentation, the other participants of the course are obliged to ask questions and undermine theses.
The next task is to prepare a written paper by each PhD student, taking into account the relevant research workshop, especially structure and language.</td></tr>
<tr><td>Basic reference materials</td><td>Determined each year individually with doctoral students.</td></tr>
<tr><td>Other reference materials</td><td>None</td></tr>
<tr><td>Average student workload outside classroom</td><td>30</td></tr>
<tr><td>Comments</td><td></td></tr>
<tr><td>Last update</td><td></td></tr>
</table>

<table>
<tr><td>Course code</td><td>CC3</td></tr>
<tr><td>Type and description</td><td></td></tr>
<tr><td>ECTS credit</td><td>2</td></tr>
<tr><td>Course name</td><td>Conducting research in the field of architecture and urban planning III</td></tr>
<tr><td>Course name in Polish</td><td>Prowadzenie badań w dyscyplinie architektura i urbanistyka III</td></tr>
<tr><td>Language of instruction</td><td>English</td></tr>
<tr><td>Course level</td><td>8 PRK</td></tr>
<tr><td>Course coordinator</td><td>dr hab. inż. Jan Salm</td></tr>
<tr><td>Course instructors</td><td>dr hab. inż. Jan Salm, dr hab. inż. Bartosz M. Walczak</td></tr>
<tr><td>Delivery methods and course duration</td><td>
<table>
<tr><th></th><th>Lecture</th><th>Tutorials</th><th>Laboratory</th><th>Project</th><th>Seminar</th><th>Other</th><th>Total of teaching hours during semester</th></tr>
<tr><td>Contact hours</td><td>0</td><td></td><td></td><td></td><td></td><td>0</td><td>30</td></tr>
<tr><td>E-learning</td><td>No</td><td>No</td><td>No</td><td>No</td><td>No</td><td>No</td><td></td></tr>
<tr><td>Assessment criteria (weightage)</td><td>0,00</td><td></td><td></td><td></td><td></td><td>0,00</td><td></td></tr>
</table>
</td></tr>
<tr><td>Course objective</td><td>The aim of the course
The aim of the course is to a PhD student with new methods and trends adopted in the studies of historical urban centres. Its task is to develop a research tools by presenting specific examples of comprehensive projects - studies related to various elements of the structure of historical urban centres, implemented by teams of specialists from various fields</td></tr>
<tr><td>Learning outcomes</td><td>A PhD student after completing the course is able to:
1. analyse the structure, research methodology, scope and content of studies of historical urban centres.
2. apply adequate research methods to various elements of the structure of historical urban centres.
3. Formulate own conclusions regarding studies of historical urban centres.</td></tr>
<tr><td>Assessment methods</td><td>Verification methods of learning outcomes
Assignment - effects 1,2
Presentation and discussion - effects 1,3
The final grade consists of:
The result of assignment - 60%
Presentation and discussion - 40%</td></tr>
<tr><td>Prerequisites</td><td>None</td></tr>
<tr><td>Course content with delivery methods</td><td>Seminar
Presentation of selected research examples; assigning tasks to individual participants, then their public presentations, analysis and discussion.</td></tr>
<tr><td>Basic reference materials</td><td>Determined each year individually with doctoral students.</td></tr>
<tr><td>Other reference materials</td><td></td></tr>
<tr><td>Average student workload outside classroom</td><td>30</td></tr>
<tr><td>Comments</td><td></td></tr>
<tr><td>Last update</td><td></td></tr>
</table>

Course code	CC4
Type and description	
ECTS credit	2
Course name	**Conducting research in the field of architecture and urban planning IV**
Course name in Polish	**Prowadzenie badań w dyscyplinie architektura i urbanistyka IV**
Language of instruction	English
Course level	8 PRK
Course coordinator	**Dr hab. inż. arch. Malgorzata Hanzl**
Course instructors	**Dr hab. inż. arch. Malgorzata Hanzl, Dr hab. inż. arch. Jacek Wesołowski, Prof. PŁ**
Delivery methods and course duration	**Lecture** **Tutorials** **Laboratory** **Project** **Seminar** **Other** **Total of teaching hours during semester** Contact hours 0 0 30 E-learning No No No No No Assessment criteria (weightage) 0,00 0,00
Course objective	The objective of the course 1. The objective of the course is to prepare students for conducting scientific research in the discipline of architecture and urban planning - writing of scientific articles, including their structure, choice of keywords, abstract, and choice of proper language. 2. Furthermore, the objective is to develop skills of choice and application of the research methodology to the specific case study.
Learning outcomes	A PhD student after completing the course can: 1. choose the appropriate article structure following the needs. 2. propose the research methodology proper for papers on contemporary architecture and urban planning. 3. critically approach sources of different provenience, including these coming from fields of science different than architecture. 4. present and discuss results of research on architecture and urban planning.
Assessment methods	Verification methods of learning outcomes effects 1-4 - presented written work effects 1-4 - presentation and discussion The final grade consists of: The result of the written text - 80% Presentation and discussion - 20%
Prerequisites	None
Course content with delivery methods	Seminar At the class, the PhD students learn about the proposed research methodology in the field of contemporary urbanism - for instance, theory of communication - or propose their own, depending on their individual needs. Next, the proposed method is applied to a specific case study. The seminar class provide an opportunity for reflection and discussion on a given topic .The next task is elaboration of their own written work which takes into account the rules of writing of articles, in this number their structure and language.
Basic reference materials	Determined each year individually with doctoral students.
Other reference materials	

Average student workload outside classroom	30
Comments	
Last update	

Załącznik nr 7
do Programu Kształcenia w ISD PŁ –
ścieżka kształcenia w dyscyplinie
Inżynieria chemiczna

TRAINING PROGRAM IN DISCIPLINE:
Chemical Engineering

1. Basic information

Domain: Engineering and Technology
Discipline: Chemical engineering
Degree awarded: PhD in Chemical engineering

Name: DSc. Eng. Marcin Bizukojć
Email: marcin.bizukojc@p.lodz.pl

2. Lecturers

No	Name and surname	Title/degree	Website/ORCID
1	Marcin Bizukojć	dr hab. inż./ prof. ndzw. PŁ	http://www.staff.wipos.p.lodz.pl/29,Marcin_Bizukojc
2	Sebastian Borowski	dr hab. inż.	http://mikrobiologia.p.lodz.pl/sebastian-borowski/
3	Andrzej Górak	prof. dr hab. inż./ prof. ndzw. PŁ	http://www.fvt.bci.tu-dortmund.de/cms/en/staff/Prof/index.html
4	Władysław Kamiński	prof. dr hab. inż.	http://www.staff.wipos.p.lodz.pl/158,Wladyslaw_Kaminski
5	Andrzej Krasławski	prof. dr inż./ prof. ndzw.	https://www.researchgate.net/profile/Andrzej_Kraslawski
6	Dorota Kręgiel	dr hab. inż./ prof. ndzw. PŁ	http://mikrobiologia.p.lodz.pl/dorota-kregiel/
7	Joseph Clarke	prof. dr eng.	https://www.strath.ac.uk/staff/clarkejosephandrewprof/
8	Rajendra Prasad Chhabra	prof. dr eng.	https://www.iitk.ac.in/che/rpc.htm
9	Charles Fleischmann	prof. dr eng.	https://www.canterbury.ac.nz/engineering/schools/cnre/postgraduate-study-options/fire/fire-engineering-contacts/charles-fleischmann.html
10	Oliver Kayser	prof. dr eng.	http://www.tb.bci.tu-dortmund.de/cms/de/home/mitarbeiter/leiter/Oliver_Kayser.html
11	Laurence Weatherley	prof. dr eng.	https://cpe.ku.edu/laurence-weatherley

3. Training demand

The current demand for highly qualified engineering staff is very high and comes from the needs of higher education and research institutes, both in Poland and abroad. Our own analysis shows

that doctoral candidates often receive their job offers even during their studies. Some of them are sent to study by their employers. Rapid development of economy, science and industry, allows for the assumption that this trend will continue in the coming years.

4. Detailed entry requirements

The formal requirement for candidates is the graduation from MSc course in chemical engineering or other technical course of a similar scope. In addition, the candidate should demonstrate the ability to work on their own, the ability to acquire and apply knowledge from various fields, as well as demonstrate predispositions for the objective analysis and evaluation of the collected observations and experimental results.

5. Teaching methods

Lectures, tutorials, laboratories, projects, seminars, e-learning.

6. Graduate's profile

The graduates of the Interdisciplinary Doctoral School at Lodz University of Technology in the discipline chemical engineering are fully skilled persons in terms of the scientific knowledge in chemical and process engineering. By developing their scientific and professional career they improve the practical applications of this area of knowledge, also taking the environmental problems into account, developing and designing research and industrial installations. In the course of training they gain the knowledge related to the most advanced technologies and development trends under the supervision of lecturers from Polish and foreign scientific centers and ultimately doctoral candidates are directed to thoroughly study the issues related to their individual doctoral theses. Advanced design and laboratory work prepare these young scientists for the tasks related to the creation of their own research teams, managing R&D departments in enterprises, creating the consortia for developing new technologies, development of products, processes and services as well as creating the independent entities like Spin off/out or Start-ups. In addition, they gain knowledge required to work in the institutions related to the technical and process safety. They can also modify, evaluate and consult new technological and product solutions in terms of their efficiency, profitability and innovativeness, also in the wider context of a sustainable and low-carbon circular economy.

For the specialists in this area all industries and institutions associated with advanced chemical engineering are open. These are processing, chemical, pharmaceutical and food industries, energy production, renewable energy sources sector. Referring to the experience of economies of innovation leaders, we are fully convinced that people with a PhD degree in chemical engineering are not only talented scientists but they also represent the most valuable and creative background - as the middle and senior management in the industry and business. They also create breakthrough technologies and solutions in the leading research and development centers. The important sectors of the employment for our graduates are also state and local government administration institutions as well as NGOs. They seek our graduates as their expert, consultative and supervisory employees to ensure environmental safety, safety of production processes and products.

7. Training plan

Semester 1									
No.	Abbreviation	Course name							ECTS
			L	T	L	P	S	Σ	
1	E	Entrepreneurship	15					15	1
2	CC1	Transport phenomena	60					60	4
Total								75	5
Semester 2									
No.	Abbreviation	Course name							ECTS

			L	T	L	P	S	Σ	
1	CC2	Green chemistry and engineering	60					60	4
Total								60	4
TOTAL								**135**	**9**

Course code	CC1
Type and description	CC – core curriculum
ECTS credit	4
Course name	**Transport phenomena**
Course name in Polish	**Zjawiska przenoszenia**
Language of instruction	English
Course level	8 PRK
Course coordinator	Prof. Dr. Rajendra Prasad Chhabra - Indian Institute of Technology, Kanpur, India
Course instructors	
Delivery methods and course duration	**Lecture** / **Tutorials** / **Laboratory** / **Project** / **Seminar** / **Other** / **Total** Contact hours: 30 / 30 / / / 0 / 60 / 60 E-learning: No / No / No / No / No / No Assessment criteria: 50% / 50%
Course objective	Provide the knowledge on the fundamental principles (three pillars: momentum, heat and mass transfer) of chemical engineering.
Learning outcomes	The doctoral candidate can: 1. describe the momentum, heat and transfer phenomena with the use of valid mathematical tools (***W1, U2, K1)*** 2. discuss the analogies between momentum, heat and transfer phenomena (***U2, K1)*** 3. apply the knowledge of transfer processes to describe the unite operation in chemical engineering (***U1, U3, K1)***
Assessment methods	The final grade consists of: Exam - 100%
Prerequisites	None
Course content with delivery methods	Lecture: 1. Momentum transfer, basic laws of fluid mechanics, balance of energy in the flow, flow in the tube and other systems 2. Mechanisms of heat transfer: conduction, convection radiation for various geometries 3. Mechanism of mass transfer: diffusion convection Tutorials: - performing calculations connected with momentum, heat, and mass transfer
Basic reference materials	Robert H. Perry (ed.) “PERRY’S CHEMICAL ENGINEERS’ HANDBOOK” McGraw and Hill, New York
Other reference materials	Materials of the lecturer
Average student workload outside classroom	15h
Comments	
Last update	

Course code	CC2
Type and description	CC - Core curriculum
ECTS credit	4
Course name	**Green chemistry and engineering**
Course name in Polish	**Zielona chemia i inżynieria**
Language of instruction	English
Course level	8 PRK
Course coordinator	Prof. Dr. Laurence Weatherley - University of Kansas, USA
Course instructors	
Delivery methods and course duration	**Lecture** **Tutorials** **Laboratory** **Project** **Seminar** **Other** **Total of teaching** Contact hours 30 30 0 60 E-learning No No No No No No Assessment criteria 50% 50%
Course objective	Providing knowledge of the modern technologies in chemical industry that are safe for the environment
Learning outcomes	Doctoral candidate can: - describe the idea of green technology (***W1, U2, K1)*** - discuss on the given technology and describe its advantages and disadvantages from ecological point of view (***U2, K1)*** - propose modification of the contemporary technologies to make them more environment-friendly (***U1, U3, K1)***
Assessment methods	The final grade consists of: Exam - 100%
Prerequisites	none
Course content with delivery methods	Lecture: - the idea of green chemistry and technology - examples of green technology - development of technologies used in the chemical industry Tutorials: - discussion on green technologies and their development
Basic reference materials	Materials of the lecturer
Other reference materials	none
Average student workload outside classroom	15
Comments	
Last update	

Załącznik nr 8
do Programu Kształcenia w ISD PŁ –
ścieżka kształcenia w dyscyplinie
Nauki chemiczne

TRAINING PROGRAM IN DISCIPLINE:
Chemical Sciences

1. Basic information

Domain: Natural Sciences
Discipline: Chemical sciences
Degree awarded: PhD in Chemical sciences
Program Coordinator:
Name: prof. dr hab. Inż. Dariusz M. Bieliński
Email: dbielin@p.lodz.pl

2. Lecturers

No	Name and surname	Title/degree	Website/ORCID
1.	Halina Abramczyk	prof. dr hab.	0000-0002-7222-3583
2.	Łukasz Albrecht	prof. dr hab. inż.	0000-0002-4669-7670
3.	Dariusz M. Bieliński	prof. dr hab. inż.	0000-0003-0675-4594
4.	Katarzyna Błażewska	dr hab. inż.	0000-0002-1218-7111
5.	Beata Brożek-Płuska	dr hab. inż., prof. PŁ	0000-0001-6924-2655
6.	Agnieszka Czylkowska	dr hab. inż., prof. PŁ	0000-0001-7157-5408
7.	Agnieszka Dybała-Defratyka	dr hab. inż., prof. PŁ	0000-0002-8939-2279
8.	Marek Główka	prof. dr hab. inż.	0000-0002-8171-6582
9.	Tomasz Gozdek	dr inż.	0000-0003-4756-8499
10.	Jacek Grams	dr hab. inż., prof. PŁ	0000-0002-5087-7068
11.	Krzysztof Hałagan	dr inż.	0000-0001-6412-2910
12.	Jarosław Jung	dr hab. inż.	0000-0001-6081-5605
13.	Sławomir Kadłubowski	dr hab. inż.	0000-0003-0648-5208
14.	Beata Kolesińska	prof. dr hab. inż.	0000-0002-4581-947X
15.	Marcin Kozanecki	dr hab. inż.	0000-0001-7400-6315
16.	Rafał Kruszyński	dr hab. inż.	0000-0003-1667-4379

17.	Grażyna Leszczyńska	dr hab. inż.	0000-0002-6874-022X
18.	Beata Łuszczyńska	dr hab. inż.	0000-0002-4274-4222
19.	Magdalena Maciejewska	dr hab. inż.	0000-0001-7110-290X
20.	Krzysztof Matyjaszewski	prof. dr hab.	0000-0003-1960-3402
21.	Lidia Okrasa	dr hab. inż.	0000-0002-0710-0392
22.	Alicja Olejnik	dr	0000-0001-7397-009X
23.	Barbara Pacholczyk-Sienicka	dr inż.	0000-0001-9767-7429
24.	Joanna Pietrasik	dr hab. inż., prof. PŁ	0000-0001-7438-9627
25.	Wojciech Pisula	prof. dr hab.	0000-0002-5853-1889
26.	Radosław Podsiadły	dr hab. inż., prof. PŁ	0000-0002-7822-8182
27.	Piotr Polanowski	dr hab., prof. PŁ	0000-0003-3801-5286
28.	Agnieszka Ruppert	dr hab. inż., prof. PŁ	0000-0001-5704-2461
29.	Mariusz Siciński	dr inż.	0000-0001-8083-1848
30.	Natalia Sienkiewicz	dr inż.	0000-0002-2187-4335
31.	Adam Sikora	dr inż.	0000-0002-4962-8945
32.	Anna Strąkowska	dr inż.	0000-0001-8019-9926
33.	Krzysztof Strzelec	prof. dr hab. inż.	0000-0001-6450-4337
34.	Dorota Światła-Wójcik	prof. dr hab. inż.	0000-0002-8863-9807
35.	Jacek Ulański	prof. dr hab.	0000-0003-1834-8470
36.	Piotr Ulański	prof. dr hab. inż.	0000-0002-4310-3574
37.	Radosław Wach	dr inż.	0000-0001-7311-4525
38.	Wojciech Wolf	prof. dr hab. inż.	0000-0002-9162-9933
39.	Marian Wolszczak	dr hab. inż., prof. PŁ	0000-0002-2448-7947

3. Training demand

The Faculty of Chemistry of the Lodz University of Technology is the only one in the central part of Poland to educate doctors of science and natural sciences in the discipline of chemical science, in 1. chemistry or 2. chemical technology, having engineering background. The studies shall prepare the candidate for work in research units, research and development units, universities - especially technical universities - by gradually introducing the candidate to research work using the latest achievements and results of scientific work in the field of doctoral studies chosen by the candidate. After obtaining doctorate, the graduates have not only extensive knowledge of chemistry and chemical

technology, but also the ability to pose, analyze and propose solutions to problems and their synthetic description. These features allow them to adapt flexibly to work in areas not only related to chemistry.

4. Detailed entry requirements

Graduates from master courses of the following faculties are accepted for studies: chemistry, chemical technology, chemical engineering, material engineering, physics and related fields (e. g. biochemistry, biophysics), not necessarily completed at polytechnic faculties. In addition, the candidate should demonstrate the ability to work independently, to acquire and apply knowledge in a variety of fields, and to demonstrate aptitude for objective analysis and evaluation of the observations made and collected results of the tests.

5. Teaching methods

Lectures, tutorials, laboratories, projects, seminars, e-learning

6. Graduate’s profile

The training prepare graduates to work in research and development units and universities, especially technical universities. The graduate has extensive and in-depth knowledge of concepts, principles and theories in the field of chemistry and chemical technology, with particular emphasis on the areas related to the prepared thesis, which was gained under the supervision of lecturers, including those from renowned foreign centres. The graduate is prepared to work with the use of modern research techniques, knows the mechanisms for raising funds for scientific research and implementation work from both domestic and international sources, and is prepared to work independently or in a group - including international ones. Advanced design and laboratory works prepare young scientists for tasks related to creating their own research teams, managing R&D departments in enterprises, creating consortia developing new technologies, developing products, processes and services - as well as creating independent entities such as Spin off/out or Start-ups. They can also modify, assess and consult on new technological and product developments in terms of their efficiency, cost-effectiveness and innovativeness - including in the broader context of a sustainable and low-carbon circular economy. Graduates are able to conduct didactic classes at the first and second level of studies, they are also able to conduct scientific research in accordance with the rules of ethics in science and technology. Graduates understand the need for continuous learning and maintaining the ethos of research community.

The specialists in this areas are also awaited by industries and institutions related to advanced materials, technology of production and processing. It is primarily the chemical industry in its broadest sense, but also, among others, the agro-food industry, pharmaceuticals, construction chemicals, transport and automotive industry. Based on the experience of innovation leader economies, it can be said with confidence that doctorate holders in chemical sciences are not only talented scientists, but also the most valuable and creative individuals - as middle and senior management both in industry and business. This group also creates breakthrough material solutions and technologies in leading research and development centres. An important sector of employment are also institutions of state and local government administration as well as NGOs, seeking these graduates for their tasks of expert, opinion-forming, supervisory, ensuring the safety of the environment, production processes, work, products, etc.

7. Training plan

Semester 1									
No.	Abbreviation	Course name	L	T	L	P	S	Σ	ECTS
1	E	Entrepreneurship	15					15	1
2	CC1	Advanced Inorganic Chemistry	25					25	2
3	CC2	Advanced Organic Chemistry	25					25	2
Total								65	5
Semester 2									
No.	Abbreviation	Course name	L	T	L	P	S	Σ	ECTS
1	CC3	Advanced Physical Chemistry	25					25	2
Total								25	2
Semester 3									
No.	Abbreviation	Course name	L	T	L	P	S	Σ	ECTS
1	CC4	Advanced Molecular and Macromolecular Science	30			7	8	45	2
Total								45	2
TOTAL								**135**	**9**

Course code	CS_CC1
Type and description	**CC** - Core Course
ECTS credit	2
Course name	**Advanced Inorganic Chemistry**
Course name in Polish	Zaawansowana chemia nieorganiczna
Language of instruction	English
Course level	8 PRK
Course coordinator	prof. dr hab. inż. Wojciech Wolf
Course instructors	prof. dr hab. inż. Wojciech Wolf, prof. dr hab. inż. Marek Główka, dr hab. inż. Agnieszka Czylkowska

Delivery methods and course duration

	Lecture	Tutorials	Laboratory	Project	Seminar	Other	Total of teaching hours during semester
Contact hours	25	0	0	0	0	0	25
E-learning	No	No	No	No	No	No	
Assessment criteria (weightage)	1.00	0.00	0.00	0.00	0.00	0.00	

Course objective

Providing the advanced knowledge on the current inorganic chemistry. Revealing connections between structure (molecular and supramolecular) of inorganic compounds and their properties, including theory and methods which can be applied in the development and synthesis of new compounds with demanded properties. Presenting of the descriptive models of inorganic compounds structure. Showing the contemporary concepts of the advanced inorganic solution chemistry.

Learning outcomes

At the end of the course the student is able to:
1. describe the principles and concepts of contemporary inorganic chemistry – ***effects W1, U2, K1***
2. discuss and define the chemical and physicochemical properties of different types of inorganic compounds – ***effects U2, K1***
3. correlate the chemical and physicochemical properties of a compound with its structure – effects U1, K1
4. identify the applications of inorganic compounds ***– effects W1, U2, K1***
5. design a synthesis method of an inorganic compound with demanded structure and properties – ***effects U1, U3, K1***
6. describe analytical methods used in contemporary inorganic chemistry – ***effects W1, U2***

Assessment methods

Verification of learning outcomes:
Effects 1-6: preparation of a written work on a given subject
The final grade consists of:
The preparation of a written work - 100%

Prerequisites

Basic knowledge of inorganic chemistry, organic chemistry, analytical chemistry and crystallography

Course content with delivery methods

LECTURE
1. principles and concepts of advanced inorganic chemistry
2. intricate inorganic and coordination compounds
3. coordination polymers and supramolecular inorganic compounds
4. experimental methods used in contemporary inorganic chemistry
5. synthesis methods of inorganic chemistry (including sonochemical and solvothermal methods)
6. solid state chemistry of inorganic compounds
7. order, periodicity and structural repeatability in solid state
8. activation of inorganic molecules
9. advanced inorganic solution chemistry
10. descriptive models of inorganic compounds structure
11. the correlation of properties with the structure of the inorganic compounds.

Basic reference materials

1. Materials provided by the lecturer.
2. F. Albert Cotton, Geoffrey Wilkinson, Carlos A. Murillo, Manfred Bochmann, Advanced Inorganic Chemistry, 6th Edition, A Wiley-Interscience publication.
3, Supramolecular Chemistry, 2nd Edition, Jonathan W. Steed B.Sc., Ph.D., Jerry L. Atwood B.S., Ph.D.,John Wiley & Sons, Ltd.

Other reference materials

1. Scientific articles on the contemporary inorganic chemistry.
2. Recommended journals: Inorganic Chemistry, Dalton Transactions, Crystal Growth and Design, CrystEngComm and Ultrasonics Sonochemistry.

Average student workload outside classroom	30 hrs
Comments	-
Last update	2019-03-09

Course code	CC2
Type and description	**CC** – Core Course
ECTS credits	2
Course name	**Advanced Organic Chemistry**
Course name in Polish	Zaawansowana Chemia Organiczna
Language of instruction	English
Course level	8 PRK
Course coordinator	prof. dr hab. inż. Łukasz Albrecht
Course instructors	prof. dr hab. inż. Łukasz Albrecht
Delivery methods and course duration	

	Lecture	Tutorials	Laboratory	Project	Seminar	Other	Total of teaching hours during semester
Contact hours	25	0	0	0	0	0	25
E-learning	No	No	No	No	No	No	
Assessment criteria (weightage)	1.00	0.00	0.00	0.00	0.00	0.00	

Course objective	The goal of the course is to familiarize students with the basic knowledge and concepts of advanced organic chemistry related to reactive intermediates (such as carbocations, carbanions, radicals or carbenes) and typical organic reaction mechanisms. During the lecture methods to predict the reactivity of organic compounds based on their structure and reaction conditions will be discussed. Furthermore, the ability to predict feasible reaction mechanism using curved-arrow notation will be acquired.
Learning outcomes	A PhD student after completing the course (***W1 P8S_EG, U1 P8S_UW, K1 P8S_KK***): 1. can recognize and knows selected examples and can write using curved-arrows notation, various types of organic reaction mechanisms; 2. has the ability to apply the knowledge of previously encountered reaction mechanisms and reaction conditions to write feasible reaction mechanism for new reactions; 3. has extended knowledge on the structure, properties and rearrangements of reactive intermediates; 4. can propose a reasonable mechanistic pathway for a given type of reaction involving reactive intermediate.
Assessment methods	Verification methods of learning outcomes effects ***W1 P8S_EG, U1 P8S_UW, K1 P8S_KK*** - written exam The final grade consists of: The result of the written test - 100%
Prerequisites	none
Course content with delivery methods	LECTURE Review of organic reaction mechanisms: a) polar reactions under acidic or basic conditions; b) free radical reactions; c) pericyclic reactions (electrocyclic reactions, cycloadditions, sigmatropic rearrangements); d) transition metal-mediated and –catalyzed reactions. Carbocations: structure, reactivity and stability of carbocations. Direct observation of carbocations – superacids. Generation of carbocations. Mechanism of rearrangement of carbocations. Bridged (nonclassical) carbocations. Free radicals: generation and properties of free radicals. Structure and stereochemistry of free radicals. Nucleophilicity and electrophilicity of free radicals. Charged radicals – radicals cations and radical anions. Characteristics of reactions involving radicals. Chosen radicals reactions. Rearrangement reactions of free radicals. Intramolecular functionalization of organic compounds involving radicals intermediates – selected aspects. Carbenes: structure, stability and reactivity of carbenes. Generation of carbenes. Addition reactions. Insertion reactions. Rearrangement of carbenes. Carbanions: acidity of hydrocarbons. Structure and stability of carbanions. Carbanion character of organometallic compounds. Carbanions stabilized by functional groups. Generation and properties of enolates and chosen stabilized carbanions.
Basic reference materials	1.Materials provided by lecturer. 2. Clayden, J.; Greeves, N.; Warren, S. "Organic Chemistry", Second Edition, Oxford University Press, Oxford, 2012. 3. Smith, M. B. "March's Advanced Organic Chemistry" 7th Edition, John Wiley & Sons, New York, 2013. 4. Carey, F. A.; Sundberg, R. J. “Advanced Organic Chemistry Part A: Structure and Mechanism”, 5th ed. Springer, 2007.
Other reference materials	current scientific papers
Average student workload outside classroom	20 hrs
Comments	-

Last update	2019-04-08

Course code	CC3
Type and description	**CC** - Core Course
ECTS credits	2
Course name	**Advanced Physical Chemistry**
Course name in Polish	Zaawansowana chemia fizyczna
Language of instruction	English
Course level	8 PRK
Course coordinator	prof. dr hab. inż. Piotr Ulański
Course instructors	prof. dr hab. Halina Abramczyk, dr hab. Beata Brożek-Płuska, dr hab. inż. Sławomir Kadłubowski, dr inż. Adam Sikora, prof. dr hab. inż. Dorota Światła-Wójcik, prof. dr hab. inż. Piotr Ulański, dr hab. Marian Wolszczak

Delivery methods and course duration

	Lecture	Tutorials	Laboratory	Project	Seminar	Other	Total of teaching hours during semester
Contact hours	25	0	0	0	0	0	25
E-learning	No	No	No	No	No	No	
Assessment criteria (weightage)	0.00	0.00	0.00	0.00	0.00	1.00	

Course objective	An aim of the course is to introduce the students to the concepts, theoretical basics and applicability of advanced techniques of physical chemistry.
Learning outcomes	After the course student: 1. describes and explains fundamental concepts, theoretical basics and applicability of selected advanced techniques and methods of physical chemistry (**W1 P8S_EG**). 2. selects adequate method or technique for a given task (**U1 P8S_UW**, **K1 P8S_KK**)
Assessment methods	Verification methods of learning outcomes effects **W1 P8S_EG, U1 P8S_UW, K1 P8S_KK** - written scientific essay The final grade consists of: The result of the written essay - 100%
Prerequisites	none
Course content with delivery methods	LECTURE 1. Advanced chemical kinetics. Rapid chemical kinetic techniques: stopped-flow, flash photolysis and pulse radiolysis technique. Kinetic simulations. 2. Basics of radiation chemistry. Matrix isolation. Radiolysis of water and aqueous solutions. 3. Radiolysis of organic solvents and ionic liquids. 4. Molecular simulation concepts and applications in solution chemistry. 5. Light-scattering techniques for analysis of properties and dynamics of nanomaterials and polymers. Classical (static) Rayleigh light scattering and its analytical applications. Dynamic light scattering and related techniques. 6. Physicochemical methods in the study of organized systems. The design and development of molecular probes. 7. Chemical aspects of photodynamic antitumor therapy and diagnostic. 8. Photoelectrochemistry. Solar to fuels conversions technologies. Thermodynamics of the conversion of solar radiation. 9. Introduction to the advanced spectroscopic techniques used in chemistry, biology and medicine with the particular emphasis on problems solving to determine molecular structure. Advanced imaging techniques with the use of different types of spectroscopic techniques with particular emphasis on vibrational spectroscopy.
Basic reference materials	1. M. Spotheim-Maurizot, M. Mostafavi, T. Douki, J.Belloni (Eds.), Radiation Chemistry from Basics to Applications in Material and Life Sciences, EDP Sciences, France, 2008. 2. Christopher J. Cramer. Essentials of Computational Chemistry. Theories and Models. John Wiley & Sons, LTD 2004. 3. M.P. Allen, D.J. Tildesley, Computer Simulation of Liquids, Oxford University Press, Oxford, 1987.
Other reference materials	Current scientific articles, given by the lecturer.
Average student workload outside classroom	10 hrs
Comments	-
Last update	2019-04-10

Course code	CC4
Type and description	CC - Core Course
ECTS credits	2
Course name	Advanced Molecular and Macromolecular Materials Science
Course name in Polish	Zaawansowana Inżynieria Materiałów Molekularnych i Makromolekularnych
Language of instruction	English
Course level	8 PRK
Course coordinator	prof. dr hab. Krzysztof Matyjaszewski / prof. dr hab. Wojciech Pisula
Course instructors	prof. dr hab. Krzysztof Matyjaszewski, prof. dr hab. Wojciech Pisula, dr hab. inż. Joanna Pietrasik, prof. dr hab. Jacek Ulański, dr hab. inż. Beata Łuszczyńska
Delivery methods and course duration	

	Lecture	Tutorials	Laboratory	Project	Seminar	Other	Total of teaching hours during semester
Contact hours	30	0	0	7	8	0	45
E-learning	No	No	No	No	No	No	
Assessment criteria (weightage)	0.60	0.00	0.00	0.30	0.10	0.00	

Course objective	The aim of the course is to enable students to acquire knowledge in the field of the relationship between the chemical and supramolecular structure and the properties of molecular and macromolecular materials. In particular, problems of molecular materials and nanomaterials as well as macromolecular engineering will be discussed from the point of view of materials applications. Students get acquainted with advanced methods of synthesis and processing of functional materials, such as, for example, reversible deactivation radical polymerizations, self-assembly, etc.
Learning outcomes	A PhD student after completing the course can: 1. characterize the relationship between structure and material properties - effects *W1 P8S_EG, U1 P8S_UW* 2. describe the theoretical basis defining the properties of materials - effects *W1 P8S_EG, U1 P8S_UW* 3. choose appropriate methods of synthesis and material processing - effects - *W1 P8S_EG, U1 P8S_UW, K1 P8S_KK*
Assessment methods	Verification methods of learning outcomes effects *W1 P8S_EG, U1 P8S_UW, K1 P8S_KK* - written exam effect *W1 P8S_EG, U1 P8S_UW, K1 P8S_KK* - project preparation effect *K1 P8S_KK* - project presentation The final grade consists of: The result of the written exam - 60% Result from the project evaluation - 30 Presentation - 10%
Prerequisites	none
Course content with delivery methods	LECTURE, part I Introduction to the macromolecular engineering; living and controlled polymerization The basic elements of controlled ion polymerization Basics of controlled radical polymerization Atom Transfer Radical Polymerization (ATRP)) ATRP - synthesis (catalysts and initiators) Architectural control of macromolecules - topology (branched, comb-branched macromolecules) Architecture control of macromolecules - composition of copolymers (statistical, block, gradient copolymers) Architecture control of macromolecules - functionalization Hybrid polymers with inorganic and biological elements Applications and industrial products obtained by controlled polymerization methods LECTURE, part II Selected, current issues in chemistry and physics of organic solids (molecular crystals, liquid crystals, amorphous materials, polymers) and nanomaterials (nanoparticles, nanocomposites) organic, inorganic and hybrid and used in the field of nanotechnology. Relations between the chemical structure and supramolecular structure, and properties of molecular materials and nanomaterials. The role of self-organization in the production of molecular materials and nanomaterials with the desired supramolecular structure. The possibilities of their applications in electronics, biology, environmental protection and medicine. PROJECT Designing the molecular structure of polymers with a specific target application. Development of a methodology for the production of molecular materials and functional nanomaterials using advanced processing methods. SEMINAR

	Critical analysis of the literature related to the discussed research problems.
Basic reference materials	1. Tutor's materials. 2. A.H.E. Mueller, K. Matyjaszewski; eds.: Controlled and Living Polymerizations: From Mechanisms to Materials, Wiley-VCH, Weinheim, 2009. 3. T.P. Davis, K. Matyjaszewski eds.: Handbook of Radical Polymerization, Willey, 2002. 4. K. Matyjaszewski, Y. Gnanou, L. Leibler eds.: Macromolecular Engineering: Precise Synthesis, Materials Properties, Applications - Volume 1-4, Willey-VCH, 2007. 5. B. Łuszczyńska, K. Matyjaszewski, J. Ulański eds.: Solution processable components for organic electronics, Wiley VCH, 2019. 6. A.G. Davies, J.M.T. Thompson eds.: Advances in Nanoengineering, Imperial College Press, London 2007. 7. W. Jones: Organic Molecular Solids, Properties and Applications, CRC, New York. 8. H. Masuhara, H. Nakanishi, K. Sasaki eds.: Single Organic Nanoparticles, Springer, 2003. 9. V. Balzani, M. Venturi, A. Credi: Molecular Devices and Machines, Wiley-VCH, 2003. 10. J.W. Steed, J.L. Atwood: Supramolecular Chemistry, John Wiley & Sons, 2013.
Other reference materials	current scientific articles, given by the lecturer
Average student workload outside classroom	20 hrs
Comments	-
Last update	2019-04-12

Załącznik nr 9
do Programu Kształcenia w ISD PŁ –
ścieżka kształcenia w dyscyplinie
Matematyka

TRAINING PROGRAM IN DISCIPLINE: Mathematics

1. Basic information

Domain: Natural Sciences
Discipline: Mathematics
Degree awarded: PhD in Mathematics
Program Coordinator:
Name: dr hab. Marek Galewski
Email: marek.galewski@p.lodz.pl

2. Lecturers

No	Name and surname	Title/degree	Website/ORCID
1.	Grzegorz Andrzejczak	dr hab.	https://orcid.org/0000-0003-2042-5359
2.	Marek Balcerzak	prof. dr hab.	https://orcid.org/0000-0003-3808-7706
3.	Jacek Banasiak	prof. dr hab.	https://orcid.org/0000-0003-3381-0774
4.	Artur Bartoszewicz	prof. dr hab.	https://orcid.org/0000-0003-3055-4728
5.	Włodzimierz Fechner	dr hab.	https://orcid.org/0000-0002-9653-3500
6.	Lesław Gajek	prof. dr hab.	https://orcid.org/0000-0002-5231-2167
7.	Marek Galewski	dr hab.	https://orcid.org/0000-0002-3224-2456
8.	Szymon Głąb	dr hab.	https://orcid.org/0000-0001-9026-8235
9.	Jacek Jachymski	prof. dr hab.	https://orcid.org/0000-0003-0043-8945
10.	Marek Kałuszka	dr hab.	https://orcid.org/0000-0002-7118-4148
11.	Wojciech Kryszewski	prof. dr hab.	https://orcid.org/0000-0002-0738-1075
12.	Urszula Ledzewicz	prof. dr hab.	https://orcid.org/0000-0002-6447-1958
13.	Piotr Liczberski	prof. dr hab.	https://orcid.org/0000-0002-5178-0727

14.	Magdalena Nockowska-Rosiak	doktor	https://orcid.org/0000-0003-2720-1761
15.	Andrzej Okolewski	dr hab.	https://orcid.org/0000-0003-4726-9499
16.	Bogdan Przeradzki	prof. dr hab.	https://orcid.org/0000-0003-1003-0708
17.	Katarzyna Szymańska-Dębowska	dr hab.	https://orcid.org/0000-0001-9252-380X

3. Training demand

The knowledge based society requires highly skilled workers in various branches of industry, banking system, high schools ranking among the top ones, higher education and research and development units. According to through investigations mathematicians are commonly those with least unemployment rate with lowest unemployment value for the PhDs. This is a consequence of training which is being implemented and which is based on utmost scrutiny and high level analysis. Moreover, the mathematical research skills lead to the habit of checking all details and foreseeing possible opportunities which is believed to be indispensable in a modern society. With such a profile of research and related skills PhD in mathematics are valued as possible employees in areas that require sophisticated analytical skills not to be learned through traditional courses. Last but not least there is some demand of employing new instructors and assistant professors at universities and colleges in Poland due to the fact of increasing generation gap that has been observed. Moreover, graduates with attitude towards interdisciplinary research will bring some new ideas and possible influence future research directions.

4. Detailed entry requirements

Mathematics graduates are eligible for doctoral training in mathematics. The candidates are advised to get in touch with possible future supervisors and start cooperation prior to the examination procedure. Future candidates are advised to investigate topics related to seminars held in the discipline of mathematics and at Lodz University of Technology as well as the formal and informal research requirements demanded by research groups. The choice of preferable research group prior to entrance examination is warmly advised since not all existing branches of mathematics are present at LUT.

The enrolment exam includes a discussion on mathematical interests of candidates pertaining to:

A) their MSc. thesis whose main ideas are to be presented;
B) scientific achievements obtained so far- if any;
C) classical oral exam covering the following topics (questions are formulated by the comission during discussion) :

1. Mathematical analysis (continuity, differentiability and integrability of functions of one and several variables - basic notions, theorems and relations).
2. Examples of Banach spaces (space of continuous functions, spaces of integrable functions with power $p>1$ - their properties).
3. Fundamental theorems in functional analysis (Hahn-Banach, Banach-Steinhaus, open mapping, closed graph, Banach-Alaouglu) with necessary background information.
4. Fundamentals in topology (continuity, compactness, connectedness, homeomorphisms).
5. Lebesgue measure (construction, integrability, modes of convergence).
6. Basics of probability theory.

7. Linear algebra (Jordan matrices, eigenvalues, linear mappings)

5. Teaching methods

Teaching methods vary from course to course reflecting the teaching attitude towards mathematics. These comprise traditional board and chalk lectures, presentations with details being presented on the board, seminars, projects and case study problem solving. Very often a sort of mixed methods is employed. There are offered courses allowing for broadening of mathematical knowledge and developing mathematical skills. Level of the courses is based on the profile of candidates and so are the methods which would be chosen through the course.

6. Graduate's profile

Doctorate holder in mathematics knows and understands the worldwide scientific knowledge related to the area of PhD thesis and their implications for practical applications, especially in the field of engineering. The graduate can perform thorough analysis and synthesis of scientific results in order to identify and solve research task with introduction of innovative solutions and observations. The graduate can plan development and inspire others to participate in discussions, solving problems, also in international environment. The graduate is ready to start independent scientific research, undertake challenges both in science and society, putting emphasis on ethical aspects and social impact of undertaken tasks.

7. Training plan

Semester 1									
No.	Abbreviation	Course name	L	T	L	P	S	Σ	ECTS
1	E	Entrepreneurship	15					15	1
2	CC1	Modern Mathematical Analysis 1	12			3		15	1
3	CC2	Modern Mathematical Analysis 2	12			3		15	1
Total								45	3
Semester 2									
No.	Abbreviation	Course name	L	T	L	P	S	Σ	ECTS
1	CC3	Stochastic Processes I	15					15	1
2	CC4	Stochastic Processes 2	15					15	1
3	CC5	Applied Functional Analysis 1	15					15	1
4	CC6	Applied Functional Analysis 2	15					15	1
Total								60	4
Semester 3									
No.	Abbreviation	Course name	L	T	L	P	S	Σ	ECTS
1	CC7	Mathematical Methods in Life Sciences and Engineering 1	15					15	1
2	CC8	Mathematical Methods in Life	15					15	1

		Sciences and Engineering 2							
Total								30	2
TOTAL								**135**	**9**

<table>
<tr><td>Course code</td><td>CC1</td></tr>
<tr><td>Type and description</td><td></td></tr>
<tr><td>ECTS credit</td><td>1</td></tr>
<tr><td>Course name</td><td>Modern Mathematical Analysis 1</td></tr>
<tr><td>Course name in Polish</td><td>Nowoczesna Analiza Matematyczna 1</td></tr>
<tr><td>Language of instruction</td><td>English</td></tr>
<tr><td>Course level</td><td>8 PRK</td></tr>
<tr><td>Course coordinator</td><td>Wojciech Kryszewski</td></tr>
<tr><td>Course instructors</td><td>Marek Balcerzak, Wojciech Kryszewski</td></tr>
<tr><td>Delivery methods and course duration</td><td>
<table>
<tr><th></th><th>Lecture</th><th>Tutorials</th><th>Laboratory</th><th>Project</th><th>Seminar</th><th>Other</th><th>Total of teaching hours during semester</th></tr>
<tr><td>Contact hours</td><td>12</td><td>0</td><td>0</td><td></td><td>3</td><td>0</td><td>15</td></tr>
<tr><td>E-learning</td><td>No</td><td>No</td><td>No</td><td>No</td><td>No</td><td>No</td><td></td></tr>
<tr><td>Assessment criteria (weightage)</td><td>0,00</td><td></td><td></td><td></td><td></td><td>0,00</td><td></td></tr>
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<tr><td>Course objective</td><td>1. Acquisition of knowledge concerning modern methods of mathematical analysis; abstract measure theory and the theory of differentiation in Banach spaces.
2. Acquisition of knowledge on the rudiments of the Fourier analysis: convergence of Fourier series and Fourier transform.</td></tr>
<tr><td>Learning outcomes</td><td>After the course a PhD student we be able to:
1. understand and apply notions, theorems and methods of abstract measure theory and the differential calculus in Banach spaces: effects W1, U2, K3;
2. understand and study problems in function spaces with the use of the Fourier analysis methods – effects W2, U1, K1-K3
3. apply the acquired knowledge in order to study various problems in concrete mathematical problems: effects U1, K1-K3</td></tr>
<tr><td>Assessment methods</td><td>Effects W1, U2, W2 – oral examination
effects U1, K1-K3…. – presentation
The final evaluation is based on:
Exam - 80%
Presentation - 20%</td></tr>
<tr><td>Prerequisites</td><td>The contents of the master degree course on the differential and integral calculus</td></tr>
<tr><td>Course content with delivery methods</td><td>Lecture
1. Abstract measure theory: construction of measure, Borel measure, Haar and Hausdorff measures; product measures; the general Fubini theorem.
2. Measurable functions and mappings, measurability and strong measurability of vector-valued functions; abstract theory of integration.
3. Differentiability of mappings between Banach spaces; the Lusternik Theorem on submanifolds; elements of the calculus of variations. The Radon-Nikodym theorem. The Rademacher theorem.
Presentation
Compactness in function spaces: Ascoli-Arzela, Riesz-Kolmogorov or Kondraschov theorems</td></tr>
<tr><td>Basic reference materials</td><td>1. W. Ziemer, Modern Real Analysis, Springer GTM 278, 2017.
2. E. Lieb, M. Loss, Analysis, Graduate Studies in Mathematics 134, AMS, 2002
3. W. Rudin, Analiza rzeczywista i zespolona, PWN 1987</td></tr>
<tr><td>Other reference materials</td><td></td></tr>
<tr><td>Average student workload outside classroom</td><td>10 h</td></tr>
<tr><td>Comments</td><td></td></tr>
<tr><td>Last update</td><td></td></tr>
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<table>
<tr><td>Course code</td><td>CC2</td></tr>
<tr><td>Type and description</td><td></td></tr>
<tr><td>ECTS credit</td><td>1</td></tr>
<tr><td>Course name</td><td>Modern Mathematical Analysis 2</td></tr>
<tr><td>Course name in Polish</td><td>Nowoczesna Analiza Matematyczna 2</td></tr>
<tr><td>Language of instruction</td><td>English</td></tr>
<tr><td>Course level</td><td>8 PRK</td></tr>
<tr><td>Course coordinator</td><td>Wojciech Kryszewski</td></tr>
<tr><td>Course instructors</td><td>Marek Balcerzak, Wojciech Kryszewski</td></tr>
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<tr><td>E-learning</td><td>No</td><td>No</td><td>No</td><td>No</td><td>No</td><td>No</td><td></td></tr>
<tr><td>Assessment criteria (weightage)</td><td>0,00</td><td></td><td></td><td></td><td></td><td>0,00</td><td></td></tr>
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</td></tr>
<tr><td>Course objective</td><td>1. Acquisition of knowledge on the rudiments of the Fourier analysis: convergence of Fourier series and Fourier transform.
3. Acquisition of knowledge concerning Sobolev spaces and their applications in boundary value problems.</td></tr>
<tr><td>Learning outcomes</td><td>After the course a PhD student we be able to:
1. understand and apply theorems in theory of Sobolev spaces: effects W1, U2, K3;
2. understand and study problems in function spacer with the use of the Fourier analysis methods – effects W2, U1, K1-K3
3. apply the acquired knowledge in order to study various problems in concrete mathematical problems: effects U1, K1-K3</td></tr>
<tr><td>Assessment methods</td><td>Effects W1, U2, W2 – oral examination
effects U1, K1-K3…. – presentation
The final evaluation is based on:
Exam - 80%
Presentation - 20%</td></tr>
<tr><td>Prerequisites</td><td>The contents of the master degree course on the differential and integral calculus</td></tr>
<tr><td>Course content with delivery methods</td><td>Lecture
1. Elements of Fourier analysis; Fourier series and their convergence; Fourier series in Hilbert spaces.
2. Fourier and Laplace transforms; operation of convolution; applications to theory of partial differential equations.
3. Weak derivatives calculus; Sobolev spaces; interpolation and Nirenberg-Gagliardo inequalities; emebeddings of Sobolev spaces.
Presentation
Duality in spaces of continuous, integrable or Sobolev functions.</td></tr>
<tr><td>Basic reference materials</td><td>1. W. Ziemer, Modern Real Analysis, Springer GTM 278, 2017
2. E. Lieb, M. Loss, Analysis, Graduate Studies in Mathematics 134, AMS, 2002
3. W. Rudin, Analiza rzeczywista i zespolona, PWN 1987</td></tr>
<tr><td>Other reference materials</td><td></td></tr>
<tr><td>Average student workload outside classroom</td><td>10 h</td></tr>
<tr><td>Comments</td><td></td></tr>
<tr><td>Last update</td><td></td></tr>
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<table>
<tr><td>Course code</td><td>CC3</td></tr>
<tr><td>Type and description</td><td></td></tr>
<tr><td>ECTS credit</td><td>1</td></tr>
<tr><td>Course name</td><td>Stochastic processes I</td></tr>
<tr><td>Course name in Polish</td><td>Procesy stochastyczne I</td></tr>
<tr><td>Language of instruction</td><td>English</td></tr>
<tr><td>Course level</td><td>8 PRK</td></tr>
<tr><td>Course coordinator</td><td>Lesław Gajek</td></tr>
<tr><td>Course instructors</td><td></td></tr>
<tr><td>Delivery methods and course duration</td><td>
<table>
<tr><th></th><th>Lecture</th><th>Tutorials</th><th>Laboratory</th><th>Project</th><th>Seminar</th><th>Other</th><th>Total of teaching hours during semester</th></tr>
<tr><td>Contact hours</td><td>15</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>15</td></tr>
<tr><td>E-learning</td><td>No</td><td>No</td><td>No</td><td>No</td><td>No</td><td>No</td><td></td></tr>
<tr><td>Assessment criteria (weightage)</td><td>1,00</td><td></td><td></td><td></td><td></td><td>0,00</td><td></td></tr>
</table>
</td></tr>
<tr><td>Course objective</td><td>The aim of the course is:
1. to enable the acquisition of knowledge and skills in stochastic processes and time series
2. to enable the acquisition of knowledge of elementary properties/theorems concerning stochastic processes
3. to enable the acquisition of elementary knowledge of applications of stochastic processes in other sciences</td></tr>
<tr><td>Learning outcomes</td><td>After completing the course students can:
1. formulate the definition/properties of the conditional expectation with respect to a sigma-field – effects W1, U1, U2
2. give definitions/properties of basic stochastic processes/time series, describe their types and give their probabilistic properties – effects W1, U2, K3
3. apply the above knowledge to analyse mathematical models – effects U1, K1-K3</td></tr>
<tr><td>Assessment methods</td><td>Learning outcomes 1—3 (effects W1, U1, U2, K1 – K3): oral exam</td></tr>
<tr><td>Prerequisites</td><td>The student has the knowledge and skills in the basics of probability, measure and integral theory.</td></tr>
<tr><td>Course content with delivery methods</td><td>LECTURE
1. Definition and properties of the conditional expectation with respect to a sigma-field.
2. Definition of a stochastic process. The Kolmogorov Existence Theorem. Time series.
3. Basic characteristics of stochastic processes. Stationary processes. The Poisson process. The Wiener process.
4. Stopping times. Martingales, submartingales, supermartingales. Doob's optional stopping theorem. Wald's identities. Doob's decomposition theorem.</td></tr>
<tr><td>Basic reference materials</td><td>1. Kallenberg, O. (2002) Foundations of Modern Probability, 2nd ed. Springer.
2. Resnick S.I. (2013). Adventures in Stochastic Processes. Springer
3. Williams D. (2019) Probability with Martingales. 2nd ed. Cambridge University Press</td></tr>
<tr><td>Other reference materials</td><td>4. Rolski T., Schmidli H., Schmidt V., Jozef L. Teugels J.L. (1999) Stochastic Processes for Insurance and Finance John Wiley and Sons</td></tr>
<tr><td>Average student workload outside classroom</td><td>10h</td></tr>
<tr><td>Comments</td><td></td></tr>
<tr><td>Last update</td><td></td></tr>
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<table>
<tr><td>Course code</td><td>CC4</td></tr>
<tr><td>Type and description</td><td></td></tr>
<tr><td>ECTS credit</td><td>1</td></tr>
<tr><td>Course name</td><td>Stochastic processes II</td></tr>
<tr><td>Course name in Polish</td><td>Procesy stochastyczne II</td></tr>
<tr><td>Language of instruction</td><td>English</td></tr>
<tr><td>Course level</td><td>8 PRK</td></tr>
<tr><td>Course coordinator</td><td>Lesław Gajek</td></tr>
<tr><td>Course instructors</td><td></td></tr>
<tr><td>Delivery methods and course duration</td><td>
<table>
<tr><th></th><th>Lecture</th><th>Tutorials</th><th>Laboratory</th><th>Project</th><th>Seminar</th><th>Other</th><th>Total of teaching hours during semester</th></tr>
<tr><td>Contact hours</td><td>15</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>15</td></tr>
<tr><td>E-learning</td><td>No</td><td>No</td><td>No</td><td>No</td><td>No</td><td>No</td><td></td></tr>
<tr><td>Assessment criteria (weightage)</td><td>1,00</td><td></td><td></td><td></td><td></td><td>0,00</td><td></td></tr>
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</td></tr>
<tr><td>Course objective</td><td>The aim of the course is:
1. to enable the acquisition of knowledge and skills in stochastic processes and time series
2. to enable the acquisition of knowledge of elementary properties/theorems concerning stochastic processes
3. to enable the acquisition of elementary knowledge of applications of stochastic processes in other sciences</td></tr>
<tr><td>Learning outcomes</td><td>After completing the course students can:
1. give definitions/properties of basic stochastic processes/time series, describe their types and give basic probabilistic characteristics – effects W1, U2, K1
2. apply the above knowledge to analyse mathematical models – effects U1, K1, K3.</td></tr>
<tr><td>Assessment methods</td><td>Learning outcomes 1—2 (effects W1, U1, U2, K1, K3): oral exam</td></tr>
<tr><td>Prerequisites</td><td>The student has the knowledge and skills from Stochastic processes I.</td></tr>
<tr><td>Course content with delivery methods</td><td>LECTURE
1. Markov processes, Markov chains, ergodic theorem
2. Semi—Markov processes
3. Galton-Watson branching process
4. Birth-death processes</td></tr>
<tr><td>Basic reference materials</td><td>1. Kallenberg, O. (2002) Foundations of Modern Probability, 2nd ed. Springer.
2. Resnick S.I. (2013). Adventures in Stochastic Processes. Springer
3. Williams D. (2019) Probability with Martingales. 2nd ed. Cambridge University Press</td></tr>
<tr><td>Other reference materials</td><td>4. Rolski T., Schmidli H., Schmidt V., Jozef L. Teugels J.L. (1999) Stochastic Processes for Insurance and Finance John Wiley and Sons</td></tr>
<tr><td>Average student workload outside classroom</td><td>10h</td></tr>
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<table>
<tr><td>Course code</td><td>CC5</td></tr>
<tr><td>Type and description</td><td></td></tr>
<tr><td>ECTS credit</td><td>1</td></tr>
<tr><td>Course name</td><td>Applied Functional Analysis 1</td></tr>
<tr><td>Course name in Polish</td><td>Stosowana analiza funkcjonalna 1</td></tr>
<tr><td>Language of instruction</td><td>English</td></tr>
<tr><td>Course level</td><td>8 PRK</td></tr>
<tr><td>Course coordinator</td><td>Jacek Jachymski</td></tr>
<tr><td>Course instructors</td><td>Jacek Jachymski and Bogdan Przeradzki</td></tr>
<tr><td>Delivery methods and course duration</td><td>
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<tr><th></th><th>Lecture</th><th>Tutorials</th><th>Laboratory</th><th>Project</th><th>Seminar</th><th>Other</th><th>Total of teaching hours during semester</th></tr>
<tr><td>Contact hours</td><td>15</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>15</td></tr>
<tr><td>E-learning</td><td>No</td><td>No</td><td>No</td><td>No</td><td>No</td><td>No</td><td></td></tr>
<tr><td>Assessment criteria (weightage)</td><td>1,00</td><td></td><td></td><td></td><td></td><td>0,00</td><td></td></tr>
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</td></tr>
<tr><td>Course objective</td><td>1. Extending knowledge in the field of weak topologies and its applications to extreme problems.
2. Acquiring knowledge on applications of fundamental theorems of functional analysis.</td></tr>
<tr><td>Learning outcomes</td><td>After the course a student is able to:
1. Search the weak compactness of sets and weak continuity of functionals – outcomes W1, U2, K1.
2. Look for solutions of some algebraic equations in Banach spacesusing operatortheory – outcomes W2, U1, K1-K3.
3. Calculate an approximate value of some integrals and an error of estimate - outcomes U1, K1-K3.
4. Find solutions of some differential equations in Banach spaces with the help of an exponential of operator – outcomes W2, U1, K1-K3.</td></tr>
<tr><td>Assessment methods</td><td>Outcomes W1-2, U1-2 –oralexam</td></tr>
<tr><td>Prerequisites</td><td>Knowledge of basic theorems of functional analysis</td></tr>
<tr><td>Course content with delivery methods</td><td>1. Weak topology, weak compactness, a generalized Weierstrass theorem for weakly sequentially continuous functionals on subsets of reflexive Banach spaces.
2. The Hahn-Banach theorem and its applications: separation of convex sets, minimum norm problem, Cebysev approximation.
3. The Banach-Steinhaus theorem. Application: a general theorem on convergence of cubature formulas, the trapezoid formula.
4. Completeness of the operator algebra. Applications: exponential of operator, solving some algebraic and differential equations in Banach spaces.</td></tr>
<tr><td>Basic reference materials</td><td>Lecturer’s materials,
1. A. Bobrowski, Analiza funkcjonalna jeden i pół. Szkic o zupełności, Politechnika Lubelska, Lublin 2015.
2. E. Zeidler, Applied Functional Analysis. Main Principles and Their Applications, Springer-Verlag, New York 1995.</td></tr>
<tr><td>Other reference materials</td><td>W. Rudin, Analiza funkcjonalna, PWN, Warszawa 2018.</td></tr>
<tr><td>Average student workload outside classroom</td><td>10h</td></tr>
<tr><td>Comments</td><td></td></tr>
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<tr><td>Course code</td><td>CC6</td></tr>
<tr><td>Type and description</td><td></td></tr>
<tr><td>ECTS credit</td><td>1</td></tr>
<tr><td>Course name</td><td>Applied Functional Analysis 2</td></tr>
<tr><td>Course name in Polish</td><td>Stosowana analiza funkcjonalna 2</td></tr>
<tr><td>Language of instruction</td><td>English</td></tr>
<tr><td>Course level</td><td>8 PRK</td></tr>
<tr><td>Course coordinator</td><td>Bogdan Przeradzki</td></tr>
<tr><td>Course instructors</td><td>Jacek Jachymski and Bogdan Przeradzki</td></tr>
<tr><td>Delivery methods and course duration</td><td>
<table>
<tr><th></th><th>Lecture</th><th>Tutorials</th><th>Laboratory</th><th>Project</th><th>Seminar</th><th>Other</th><th>Total of teaching hours during semester</th></tr>
<tr><td>Contact hours</td><td>15</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>15</td></tr>
<tr><td>E-learning</td><td>No</td><td>No</td><td>No</td><td>No</td><td>No</td><td>No</td><td></td></tr>
<tr><td>Assessment criteria (weightage)</td><td>1,00</td><td></td><td></td><td></td><td></td><td>0,00</td><td></td></tr>
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</td></tr>
<tr><td>Course objective</td><td>1. Acquiring knowledge In the field of Sobolev spaces and their applications to differential equations.
2. Acquiring knowledge In the field of spectra theory with applications to differentia operators and Bondary value problems.</td></tr>
<tr><td>Learning outcomes</td><td>After the course a student is able to:
1. search the spectrum of linear operators, especially differentia ones – outcomes W1, U2, K1
2. look for solutions to BVPs by using Spectral Theory – outcomes W2, U1, K1-K3
3. search regularity of solutions to differentia equations - outcomes U1, K1-K3
4. look for solutions to BVPs by using Fourier transform – outcomes W2, U1, K1-K3</td></tr>
<tr><td>Assessment methods</td><td>Outcomes W1-2, U1-2 –oralexam</td></tr>
<tr><td>Prerequisites</td><td></td></tr>
<tr><td>Course content with delivery methods</td><td>1. Sobolev spacer, embeddingtheorems.
2. Basic knowledge on Schwartz’s and tempered distributions. Fourier transform.
3. Spectrum of linear operators In Banach spaces.
4. Spectral Theorem for selfadjoint operators bouded and unbounded.
5. Applications of the spectral theory to differential operators.</td></tr>
<tr><td>Basic reference materials</td><td>1. Lecturer’s materials,
2.A. Bressan, Lecture Notes In Functional Analysis, American Mathematical Society, ProvidenceRI 2013.
3.J. Conway, A Course In Functional Analysis, Springer-Verlag, New York 1990.
4.W. Rudin, Analiza funkcjonalna, PWN, Warszawa 2018.</td></tr>
<tr><td>Other reference materials</td><td>K. Yosida, Functional Analysis, Springer-Verlag, Berlin 1980.</td></tr>
<tr><td>Average student workload outside classroom</td><td>10</td></tr>
<tr><td>Comments</td><td></td></tr>
<tr><td>Last update</td><td></td></tr>
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<table>
<tr><td>Course code</td><td>CC7</td></tr>
<tr><td>Type and description</td><td></td></tr>
<tr><td>ECTS credit</td><td>1</td></tr>
<tr><td>Course name</td><td>Mathematical Methods in life sciences and engineering 1</td></tr>
<tr><td>Course name in Polish</td><td>Metody matematyczne w naukach przyrodniczych i technicznych 1</td></tr>
<tr><td>Language of instruction</td><td>English</td></tr>
<tr><td>Course level</td><td>8 PRK</td></tr>
<tr><td>Course coordinator</td><td>Katarzyna Szymańska-Dębowska</td></tr>
<tr><td>Course instructors</td><td>J. Banasiak</td></tr>
<tr><td>Delivery methods and course duration</td><td>
<table>
<tr><th></th><th>Lecture</th><th>Tutorials</th><th>Laboratory</th><th>Project</th><th>Seminar</th><th>Other</th><th>Total of teaching hours during semester</th></tr>
<tr><td>Contact hours</td><td>10</td><td>0</td><td>0</td><td>0</td><td>5</td><td>0</td><td>15</td></tr>
<tr><td>E-learning</td><td>No</td><td>No</td><td>No</td><td>No</td><td>No</td><td>No</td><td></td></tr>
<tr><td>Assessment criteria (weightage)</td><td>0,00</td><td></td><td></td><td></td><td></td><td>0,00</td><td></td></tr>
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</td></tr>
<tr><td>Course objective</td><td>Objective of the course:

1. Acquiring knowledge on formulating models in technical and other applied sciences and identifying them within appropriate mathematical structures.
2. Acquiring knowledge in the field of functional analysis methods, partial differential equations and infinite dynamic systems used for model analysis.
3. Acquiring knowledge in the field of asymptotic methods used in multi-scale models.
4. Acquiring the ability to interpret the results of mathematical analysis of models in the context of selected applied sciences.</td></tr>
<tr><td>Learning outcomes</td><td>A PhD student after completing the course can:
1. Build and modify models based on their verbal description and available experimental data - effects W1-W2, U2, K1, K3
2. Identify models within appropriate mathematical structures - effects W1, W2, U1, K1-K3
3. Analyze models in a qualitative and quantitative way and interpret mathematical results in the language of the field from which the models come - effects of U1, U2, K1-K3</td></tr>
<tr><td>Assessment methods</td><td>The final mark consists of :

Oral exam mark - 80%

Seminar presentation - 20%</td></tr>
<tr><td>Prerequisites</td><td>Basic theory of ordinary and partial differential equations, basic course in functional analysis</td></tr>
<tr><td>Course content with delivery methods</td><td>The content of the course divided into the delivery methods:

LECTURES

1. Formulating models in technical sciences. Basic mathematical questions posed in these fields.
2. Advanced methods of partial differential equations - problems with free boundaries, variational inequalities.
3. Non-local issues and differential-integral equations in applications to polymerization /</td></tr>
</table>

	depolymerization models and related issues. 4. Methods of asymptotic analysis and state aggregation. 5. Running waves and their applications. PROJECT 1. Qualitative analysis of selected models using the methods discussed in the lecture.
Basic reference materials	1. A. Friedman, W. Littman, Industrial Mathematics: A Course in Solving Real-World Problems, SIAM, 1987 2. J. Ockendon, S. Howison, A. Lacey, A. Movchan, Applied partial differential equations, Oxford, 2003 3. A. C. Fowler, Mathematical Models in the Applied Sciences, Cambridge, 1997 4. J. D. Logan, An introduction to nonlinear partial differential equations. Wiley-Interscience, 2008 5. J. Banasiak, W. Lamb, P. Laurençot, Analytic Methods for Coagulation-Fragmentation Models, CRC Press, 2019
Other reference materials	1. J. Smoller, Shock waves and reaction-diffusion equations, Springer, 1994. 2. D. Kinderlehrer, G. Stampacchia, An introduction to variational inequalities and their applications. Academic Press, 1980. 3. C.V. Pao, C. V. Nonlinear parabolic and elliptic equations. Plenum Press, 1992.
Average student workload outside classroom	10 h
Comments	
Last update	

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<tr><td>Course code</td><td>CC8</td></tr>
<tr><td>Type and description</td><td></td></tr>
<tr><td>ECTS credit</td><td>1</td></tr>
<tr><td>Course name</td><td>Mathematical Methods in life sciences and engineering 2</td></tr>
<tr><td>Course name in Polish</td><td>Metody matematyczne w naukach przyrodniczych i technicznych 2</td></tr>
<tr><td>Language of instruction</td><td>English</td></tr>
<tr><td>Course level</td><td>8 PRK</td></tr>
<tr><td>Course coordinator</td><td>Jacek Banasiak</td></tr>
<tr><td>Course instructors</td><td>Katarzyna Szymańska-Dębowska</td></tr>
<tr><td>Delivery methods and course duration</td><td>
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<tr><th></th><th>Lecture</th><th>Tutorials</th><th>Laboratory</th><th>Project</th><th>Seminar</th><th>Other</th><th>Total of teaching hours during semester</th></tr>
<tr><td>Contact hours</td><td>10</td><td>5</td><td>0</td><td>0</td><td>0</td><td>0</td><td>15</td></tr>
<tr><td>E-learning</td><td>No</td><td>No</td><td>No</td><td>No</td><td>No</td><td>No</td><td></td></tr>
<tr><td>Assessment criteria (weightage)</td><td>0,00</td><td></td><td></td><td></td><td></td><td>0,00</td><td></td></tr>
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</td></tr>
<tr><td>Course objective</td><td>Objective of the course:
1. Acquiring knowledge in the field of basic concepts related to PDEs systems with free boundary;
2. Acquiring knowledge in the field of proving theorems and investigating the properties of radially symmetric solutions of PDEs systems with free boundary;
3. Gaining knowledge in the field of application of PDEs with free boundary.</td></tr>
<tr><td>Learning outcomes</td><td>A PhD student after completing the course can:
1. Examine the basic properties of solutions of selected of PDEs systems with free boundary, examine the properties of the radius of the free boundary - effects W1, W2, U1, U2
2. Examine the basic properties of radially symmetric solutions of selected of PDEs systems with free boundary, examine the properties of the of the radius of the free boundary - effects W1, W2, U1
3. Apply the acquired knowledge to the analysis of specific mathematical models: effects W1, U1, U2, K1-K3</td></tr>
<tr><td>Assessment methods</td><td>The final mark consists of :

Oral exam mark - 80%

Seminar presentation - 20%</td></tr>
<tr><td>Prerequisites</td><td>Basic theory of ordinary and partial differential equations and dynamical systems.</td></tr>
<tr><td>Course content with delivery methods</td><td>The content of the course divided into the delivery methods:

LECTURES

1. Problems on a set with a free boundary, with flux and no flux.

2. Study of the properties of solutions to boundary problems and the behaviour of the boundary using known theorems from partial equations, for example the maximum principle.</td></tr>
</table>

	3. Considering the problem in radially symmetrical case. 4. Study of the properties of radially symmetrical solutions of boundary problems and the behaviour of the radius of the boundary. 5. Search for stationary solutions using the shooting method. PROJEKT 1. Prezentacja analizy konkretnego modelu. PROJECT 1 Presentation of the analysis of a particular model. 2. Discussing the mathematical methods presented in the presentation.
Basic reference materials	1. A. Friedman, Mathematical biology. Modeling and analysis. CBMS Regional Conference Series in Mathematics, 127. Published for the Conference Board of the Mathematical Sciences, Washington, DC; by the American Mathematical Society, Providence, RI, 2018. 2. A. Friedman, K.Y. Lam, On the stability of steady states in a granuloma model. J. Differential Equations 256 (2014), no. 11, 3743–3769. 3. A. Friedman, Free boundary problems arising in biology. Discrete Contin. Dyn. Syst. Ser. B 23 (2018), no. 1, 193–202.
Other reference materials	
Average student workload outside classroom	10 h
Comments	
Last update	

Załącznik nr 10
do Programu Kształcenia w ISD PŁ –
ścieżka kształcenia w dyscyplinie
Nauki Fizyczne

TRAINING PROGRAM IN DISCIPLINE: Physical Sciences

1. Basic information

Domain: Natural Sciences
Discipline: Physical Sciences
Degree awarded: PhD in Physical Sciences
Program Coordinator:
Name: dr hab. inż.. Jolanta Prywer, prof. PŁ
Email: jolanta.prywer@p.lodz.pl

2. Lecturers

No	Name and surname	Title/degree	Website/ORCID
1.	Jolanta Prywer	dr hab. inż. prof. PŁ	https://fizyka.p.lodz.pl/en/employees/
2.	Jaromir Tosiek	dr hab. inż.	https://fizyka.p.lodz.pl/en/employees/
3.	Michał Dobrski	dr inż.	https://fizyka.p.lodz.pl/en/employees/
4.	Katarzyna Pernal	prof. dr hab.	https://fizyka.p.lodz.pl/en/employees/
5.	Ewa Pastorczak	dr inż.	https://fizyka.p.lodz.pl/en/employees/
6.	Tomasz Czyszanowski	dr hab. inż. prof. PŁ	https://fizyka.p.lodz.pl/en/employees/
7.	Michał Wasiak	dr hab. inż.	https://fizyka.p.lodz.pl/en/employees/
8.	Maciej Dems	dr hab. inż.	https://fizyka.p.lodz.pl/en/employees/
9.	Mariola Buczkowska	dr hab. inż.	https://fizyka.p.lodz.pl/en/employees/
10.	Włodzimierz Kucharczyk	prof. dr hab.	https://fizyka.p.lodz.pl/en/employees/

3. Training demand

The PhD training program in physics prepares the PhD candidates for work in research units, research and development units, universities - especially technical universities. The aim of the training program is to gradually introduce a candidate to research work and expose her/him to the latest achievements and scientific results in the discipline of physics. In science faculties of both technical universities and universities, there is a "generation gap" among those conducting research. There is a need for staff trained to conduct research and didactic work at faculties of exact sciences.

4. Detailed entry requirements

Completing the Master's Degree, or equivalent, in physics, chemistry or other disciplines of science, allowing a candidate to undertake a PhD program in physics.

5. Teaching methods

Lectures, tutorials, laboratory, seminars, participation in workshops, conferences. Collaborative work in research groups.

6. Graduate's profile

After completing a program in physics and obtaining a PhD degree a graduate not only has an extensive knowledge in this discipline, but also has the ability to set, analyze and propose solutions to problems and their synthetic description. A graduate is capable of establishing collaborations and conducting team research projects.

7. Training plan

Semester 1									
No.	Abbreviation	Course name	L	T	L	P	S	Σ	ECTS
1	E	Entrepreneurship	15					15	1
2	CC1	Current trends in physical sciences 1						15	1
3	CC5	Advanced research planning and management in physical sciences 1						15	1
Total								45	3
Semester 2									
No.	Abbreviation	Course name	L	T	L	P	S	Σ	ECTS
1	CC2	Current trends in physical sciences 2						15	1
2	CC6	Advanced research planning and management in physical sciences 2						15	1
Total								30	2
Semester 3									
No.	Abbreviation	Course name	L	T	L	P	S	Σ	ECTS
1	CC3	Current trends in physical sciences 3						15	1
2	CC7	Advanced research planning and management in physical sciences 3						15	1
Total								30	2
Semester 4									
1	CC4	Current trends in physical sciences 4						15	1
2	CC8	Advanced research planning and management in physical sciences 4						15	1
Total								30	2
TOTAL								**135**	**9**

<table>
<tr><td>Course code</td><td>CC1-4</td></tr>
<tr><td>Type and description</td><td>Core Curriculum in Physics</td></tr>
<tr><td>ECTS credit</td><td>1</td></tr>
<tr><td>Course name</td><td>Current trends in physical sciences</td></tr>
<tr><td>Course name in Polish</td><td>Współczesne trendy rozwoju głównych dziedzin fizyki</td></tr>
<tr><td>Language of instruction</td><td>English</td></tr>
<tr><td>Course level</td><td>8 PRK</td></tr>
<tr><td>Course coordinator</td><td>prof. dr hab. Katarzyna Pernal</td></tr>
<tr><td>Course instructors</td><td>dr hab. inż. Jolanta Prywer, dr hab. inż. Jaromir Tosiek, dr inż. Michał Dobrski, prof. dr hab. Katarzyna Pernal, dr inż. Ewa Pastorczak, prof. dr hab. Włodzimierz Kucharczyk, dr hab. inż. Mariola Buczkowska, dr hab. inż. Tomasz Czyszanowski, dr hab. inż. Michał Wasiak, dr hab. inż. Maciej Dems</td></tr>
<tr><td>Delivery methods and course duration</td><td>
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<tr><td>Contact hours</td><td>15</td><td></td><td></td><td></td><td></td><td></td><td>15</td></tr>
<tr><td>E-learning</td><td>No</td><td>No</td><td>No</td><td>No</td><td>No</td><td>No</td><td></td></tr>
<tr><td>Assessment criteria (weightage)</td><td>100%</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
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</td></tr>
<tr><td>Course objective</td><td>Exposing PhD students to current trends in physical sciences related to their research work.</td></tr>
<tr><td>Learning outcomes</td><td>A PhD student acquires knowledge at advanced level and learns about recent achievements in the physical sciences related to their field of research.</td></tr>
<tr><td>Assessment methods</td><td>Take-home exam.</td></tr>
<tr><td>Prerequisites</td><td>Completed university-level physics and mathematics courses.</td></tr>
<tr><td>Course content with delivery methods</td><td>The semester-long course content includes selected topics (to be decided by the lecturer) in one of the following fields:
advanced quantum mechanics
many-electron physics
advanced crystal physics
advanced photonics
advanced liquid crystal physics
nonlinear optics</td></tr>
<tr><td>Basic reference materials</td><td>Scientific papers and monographs recommended by a lecturer.</td></tr>
<tr><td>Other reference materials</td><td>Scientific papers.</td></tr>
<tr><td>Average student workload outside classroom</td><td>20h</td></tr>
<tr><td>Comments</td><td></td></tr>
<tr><td>Last update</td><td>24.04.2019</td></tr>
</table>

<table>
<tr><td>Course code</td><td>CC5-8</td></tr>
<tr><td>Type and description</td><td>Core Curriculum in Physics</td></tr>
<tr><td>ECTS credit</td><td>1</td></tr>
<tr><td>Course name</td><td>Advanced research planning and management in physical sciences</td></tr>
<tr><td>Course name in Polish</td><td>Zaawansowane metody planowania i zarządzania projektami badawczymi w naukach fizycznych</td></tr>
<tr><td>Language of instruction</td><td>English</td></tr>
<tr><td>Course level</td><td>8 PRK</td></tr>
<tr><td>Course coordinator</td><td>prof. dr hab. Katarzyna Pernal</td></tr>
<tr><td>Course instructors</td><td>dr hab. inż. Jolanta Prywer, dr hab. inż. Jaromir Tosiek, dr inż. Michał Dobrski, prof. dr hab. Katarzyna Pernal, dr inż. Ewa Pastorczak, prof. dr hab. Włodzimierz Kucharczyk, dr hab. inż. Mariola Buczkowska, dr hab. inż. Tomasz Czyszanowski, dr hab. inż. Michał Wasiak, dr hab. inż. Maciej Dems</td></tr>
<tr><td>Delivery methods and course duration</td><td>
<table>
<tr><th></th><th>Lecture</th><th>Tutorials</th><th>Laboratory</th><th>Project</th><th>Seminar</th><th>Other</th><th>Total of teaching hours during semester</th></tr>
<tr><td>Contact hours</td><td></td><td></td><td></td><td></td><td></td><td>15</td><td>15</td></tr>
<tr><td>E-learning</td><td>No</td><td>No</td><td>No</td><td>No</td><td>No</td><td>No</td><td></td></tr>
<tr><td>Assessment criteria (weightage)</td><td></td><td></td><td></td><td></td><td></td><td>100%</td><td></td></tr>
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</td></tr>
<tr><td>Course objective</td><td>Acquiring the skills and capabilities to conduct research and analyze acquired results in physical sciences.</td></tr>
<tr><td>Learning outcomes</td><td>A PhD student is able to analyze a given problem and propose its solution, plan and carry out a theoretical or experimental investigation leading to finding a solution, critically assess the results, verify the hypothesis, write a scientific report or a paper, present and discuss the results at international level.</td></tr>
<tr><td>Assessment methods</td><td>Activity. Assessment ways vary depending on the requirements of course instructors.</td></tr>
<tr><td>Prerequisites</td><td>Completed university-level physics and mathematics courses.</td></tr>
<tr><td>Course content with delivery methods</td><td>Course content varies depending on the course instructor and a subject of a PhD project.</td></tr>
<tr><td>Basic reference materials</td><td>Scientific papers and monographs related to the field of study.</td></tr>
<tr><td>Other reference materials</td><td></td></tr>
<tr><td>Average student workload outside classroom</td><td>20h</td></tr>
<tr><td>Comments</td><td></td></tr>
<tr><td>Last update</td><td>24.04.2019</td></tr>
</table>

Załącznik nr 11
do Programu Kształcenia w ISD PŁ –
ścieżka kształcenia w dyscyplinie
Technologia żywności i żywienia

TRAINING PROGRAM IN DISCIPLINE:
Food Technology and Nutrition

1. Basic information

Domain: Agricultural Sciences
Discipline: Food Technology and Nutrition
Degree awarded: PhD in Food Technology and Nutrition
Program Coordinator:
Name: dr hab. inż. Alina Kunicka-Styczyńska, prof. PŁ
Email: alina.kunicka-styczynska@p.lodz.pl

2. Lecturers

No	Name and surname	Title/degree	Website/ORCID
1	Aneta Białkowska	Dr hab. inż.	0000-0001-7319-238x
2	Stanisław Bielecki	Prof. dr hab. inż.	0000-0003-2089-8623
3	Grażyna Budryn	Dr hab. inż., prof. PŁ	0000-0002-8050-3702
4	Anna Diowksz	Dr hab. inż.	0000-0001-8673-8847
5	Katarzyna Dybka-Stępień	Dr inż.	0000-0002-3095-0811
6	Urszula Dziekońska	Dr inż.	0000-0002-9604-1127
7	Edyta Gendaszewska-Darmach	Dr hab. inż. prof. PŁ	0000-0003-1777-9295
8	Beata Gutarowska	Prof. dr hab.	0000-0002-9523-2001
9	Edyta Kordialik-Bogacka	Dr hab. inż.	0000-0002-4166-6074
10	Monika Kosmala	Dr hab. inż.	0000-0002-9018-3028
11	Katarzyna Kubiak	Dr inż.	0000-0003-3815-1712
12	Alina Kunicka-Styczyńska	Dr hab. inż., prof. PŁ	0000-0002-4611-9109
13	Karolina Ludwicka	Dr inż.	0000-0001-5403-7640
14	Iwona Majak	Dr inż.	0000-0002-5617-9631
15	Anna Otlewska	Dr inż.	0000-0002-3536-3560
16	Anna Podsędek	Dr hab. inż.	0000-0001-6654-4818

17	Agnieszka Pietrzyk-Brzezińska	Dr inż.	0000-0003-1565-7307
18	Katarzyna Rajkowska	Dr hab.	0000-0002-6943-8639
19	Małgorzta Redzynia	Dr inż.	0000-0003-4625-9678
20	Elżbieta Sobiecka	Dr hab. inż., prof. PŁ	0000-0003-0016-5510
21	Katarzyna Śliżewska	Dr hab. inż., prof. PŁ	0000-0002-3161-1707
22	Agnieszka Wilkowska	Dr inż.	0000-0003-1675-4387
23	Małgorzata Zakłos-Szyda	Dr inż.	0000-0001-8341-1654
24	Dorota Żyżelewicz	Dr hab. inż., prof. PŁ	0000-0003-0989-0671

3. Training demand

The doctoral training in Food Technology and Nutrition at Lodz University of Technology has a mission to multiply and disseminate knowledge, aiming at educating highly qualified staff for the needs of the economy and administration. The primary goal is to educate graduates with interdisciplinary knowledge who can use it in both research and practice. Another goal is to teach graduates the ability to present and publish results of their research and to defend their research theories. Graduates after obtaining the doctoral degree in agricultural sciences in the discipline of food and nutrition technology, due to the interdisciplinary nature and multi-directional education program have extensive knowledge related not only to the basic discipline, but also broadly understood biotechnology and chemical engineering.

4. Detailed entry requirements

A formal requirement for candidates is the completion of master's studies in food and nutrition technology or chemical engineering or other related fields. In addition candidates should demonstrate the ability to work independently, the ability to acquire and apply knowledge in various fields, as well as demonstrate predispositions for objective analysis and evaluation of collected observations and research results.

5. Teaching methods

Lectures, classes, laboratories, projects, scientific seminars

6. Graduate’s profile

Graduates know and understand scientific world and creative achievements and practical implications resulting from them. They are able to analyze and creatively synthesize scientific and creative achievements in order to identify and solve research problems and issues related to innovative and creative activities as well as to contribute to these achievements. Graduates can consciously and independently plan their development and inspire the development of other people and participate in the exchange of experiences and ideas in the national and international environment. They are ready to undertake independent studies enlarging the existing scientific and creative achievements, taking up challenges in the professional and public sphere, taking into account their ethical dimension and

responsibility for their effects and shaping patterns of proper behavior in such situations. Graduates will find employment at domestic and foreign universities as well as in research and development centers as researchers and scientists. They will be highly qualified staff of modern enterprises that implement production processes using waste-free innovative technologies in areas such as biotechnology, agriculture and food, cosmetics and pharmaceutical industries. They can also modify, evaluate and consult new technological and product solutions in terms of their efficiency, profitability and innovativeness – also in the wider context of a sustainable and low-carbon circular economy.

7. Training plan

Semester 1									
No.	Abbreviation	Course name	L	T	L	P	S	Σ	ECTS
1	E	Entrepreneurship	15					15	1
2	CC1	Modern trends in food technology I	5		10			15	1
3	CC2	Phytocompounds as bioactive food ingredients			15			15	1
Total								45	3
Semester 2									
No.	Abbreviation	Course name	L	T	L	P	S	Σ	ECTS
1	CC3	The role of phytocomponents in the prevention of civilization diseases	15					15	1
2	CC4	Advances in fermented food and beverages I	5		10			15	1
Total								30	2
Semester 3									
No.	Abbreviation	Course name	L	T	L	P	S	Σ	ECTS
1	CC5	Modern trends in food technology II	5		10			15	1
2	CC6	Biocatalysis	15					15	1
Total								30	2
Semester 4									
1	CC7	Modern microbiological analysis in food industry	8		7			15	1
2	CC8	Advances in fermented food and beverages II				15		15	1
Total								30	2
TOTAL								**135**	**9**

<table>
<tr><td>Course code</td><td>CC1</td></tr>
<tr><td>Type and description</td><td>CC1 - core curriculum for food technology and nutrition</td></tr>
<tr><td>ECTS credit</td><td>1</td></tr>
<tr><td>Course name</td><td>Modern Trends In Food Technology I</td></tr>
<tr><td>Course name in Polish</td><td>Nowoczesne trendy w technologii żywności I</td></tr>
<tr><td>Language of instruction</td><td>English</td></tr>
<tr><td>Course level</td><td>8 PRK</td></tr>
<tr><td>Course coordinator</td><td>Dr hab. inż. Grażyna Budryn, prof. PŁ</td></tr>
<tr><td>Course instructors</td><td></td></tr>
<tr><td>Delivery methods and course duration</td><td>
<table>
<tr><th></th><th>Lecture</th><th>Tutorials</th><th>Laboratory</th><th>Project</th><th>Seminar</th><th>Other</th><th>Total of teaching hours during semester</th></tr>
<tr><td>Contact hours</td><td>5</td><td></td><td>10</td><td></td><td></td><td>0</td><td>15</td></tr>
<tr><td>E-learning</td><td>No</td><td>No</td><td>No</td><td>No</td><td>No</td><td>No</td><td></td></tr>
<tr><td>Assessment criteria (weightage)</td><td>60,00</td><td></td><td>40,00</td><td></td><td></td><td>0,00</td><td></td></tr>
</table>
</td></tr>
<tr><td>Course objective</td><td>The aim of the course is to familiarize students with the latest trends on the food market, related to the use of innovative ingredients and materials in food processing</td></tr>
<tr><td>Learning outcomes</td><td>After completing the course a student can:
1. Indicate the sources of innovative food ingredients and describe the characteristics of these ingredients
2. Describe the use of new plant and animal raw materials and their ingredients in food
3. Adjust the composition of food to the needs of the entrepreneur or consumer</td></tr>
<tr><td>Assessment methods</td><td>Learning outcomes 1-2: Written test of issues covering the content of the lecture.
The assessment criteria are: integration of knowledge, compatibility of answers with the subject of the question, use of the latest literature data, ability to justify the opinion.
The result of the test: 40%.
Learning outcome 3: Completion of laboratory exercises and laboratory report.
The assessment criteria are: active participation in laboratory classes, innovative approach and the use of knowledge acquired during lectures to complete the task, completeness of the report.
The assessment of the results of laboratory work and of the report: 60%.</td></tr>
<tr><td>Prerequisites</td><td>Basics of knowledge in the field food chemistry</td></tr>
<tr><td>Course content with delivery methods</td><td>Lecture:
1. Factors influencing the food market
2. New ingredients and new types of food
3. New plant and animal raw materials in food production
Laboratory:
1. Obtaining and analyzing food products with new pro-health features
2. Innovative methods of modifying the sensory properties of food
3. Preserving the quality of food products using modern natural substances.</td></tr>
<tr><td>Basic reference materials</td><td>1. Collective authorship edited by C. Leadley: "Innovation and Future Trends in Food Manufacturing and Supply Chain Technologies", Elsevier, 2016, Berlin
2. Collective authorshipedited by F. Contoer: "Advences in Dairy Products", Jonh Wiley & Sons Ltd, 2018, New York
3. Collective authorship edited by I. Aguilo-Aguayo, L. Plaza: "Innovative Technologies in Beverage Processing" John Wiley & Sons Ltd, 2017, New York
4. Collective authorship edited by D. Ghosh, S. Das, D. Bagchi, R.B. Smarta: "Innovation in Healthy and Functional Foods" CRC Press, 2012, Booca Raton
5. Collective authorship edited by Ö. Tokuşoğlu: "Food By-Product Based Functional Food Powders" CRC Press, 2018</td></tr>
<tr><td>Other reference materials</td><td>Scientific articles from international journals in the field of food and nutrition science and technology</td></tr>
<tr><td>Average student workload outside classroom</td><td>15 h</td></tr>
<tr><td>Comments</td><td></td></tr>
<tr><td>Last update</td><td></td></tr>
</table>

Course code	CC2
Type and description	CC2 - core curriculum for food technology and nutrition
ECTS credit	1
Course name	Phytocompounds as bioactive food ingredients
Course name in Polish	Fitozwiązki jako bioaktywne składniki żywności
Language of instruction	English
Course level	8 PRK
Course coordinator	Dr hab. inż. Anna Podsędek
Course instructors	Dr inż. Małgorzata Redzynia, Dr inż. Małgorzata Zakłos-Szyda
Delivery methods and course duration	
Course objective	Students' acquaintance with the methods of analysis of the composition of phytochemicals and their pro-health activity by *in vitro* methods
Learning outcomes	After completing the course, a PhD student is able to 1. prepare extracts of phenolic compounds, antioxidant vitamins, and pigments from plant material, 2. characterize the qualitative and quantitative composition of phytochemicals by chromatographic methods, 3. determine the antioxidative potential by various methods, 4. link biological activity of phytochemicals with their composition.
Assessment methods	Learning outcomes 1-4. Written reports from laboratory classes containing results of analyses and discussion with published data, Final assessment includes: The result of reports: 100%
Prerequisites	Knowledge of organic chemistry, biochemistry
Course content with delivery methods	1. Preparation of extracts of phenolic compounds, antioxidant vitamins, pigments from plant material 2. Determination of the qualitative and quantitative composition of selected phytochemicals by chromatographic methods 3. Determination of antioxidative activity in various measurement systems 4. Study of the effect of phytochemicals on oxidative stress of cells *in vitro*
Basic reference materials	Scientific journals available in the library network of the Lodz University of Technology
Other reference materials	
Average student workload outside classroom	10 h
Comments	
Last update	

	Lecture	Tutorials	Laboratory	Project	Seminar	Other	Total of teaching hours during semester
Contacthours			15			0	15
E-learning	No	No	No	No	No	No	
Assessmentcriteria (weightage)			100,00				

<table>
<tr><td>Course code</td><td>CC3</td></tr>
<tr><td>Type and description</td><td>CC3 - core curriculum for food technology and nutrition</td></tr>
<tr><td>ECTS credit</td><td>1</td></tr>
<tr><td>Course name</td><td>The role of phytocomponents in the prevention of civilization diseases</td></tr>
<tr><td>Course name in Polish</td><td>Rola fitokomponentów w prewencji chorób cywilizacyjnych</td></tr>
<tr><td>Language of instruction</td><td>English</td></tr>
<tr><td>Course level</td><td>PhD Studies</td></tr>
<tr><td>Course coordinator</td><td>Monika Kosmala, DSc PhD eng.</td></tr>
<tr><td>Course instructors</td><td></td></tr>
<tr><td>Delivery methods and course duration</td><td>
<table>
<tr><th></th><th>Lecture</th><th>Tutorials</th><th>Laboratory</th><th>Project</th><th>Seminar</th><th>Other</th><th>Total of teaching hours during semester</th></tr>
<tr><td>Contact hours</td><td>15</td><td></td><td></td><td></td><td></td><td>0</td><td>15</td></tr>
<tr><td>E-learning</td><td>No</td><td>No</td><td>No</td><td>No</td><td>No</td><td>No</td><td></td></tr>
<tr><td>Assessment criteria (weightage)</td><td>100,00</td><td></td><td></td><td></td><td></td><td>0,00</td><td></td></tr>
</table>
</td></tr>
<tr><td>Course objective</td><td>Students' acquaintance with the role of phytocomponents in healthy human diet. Students' acquaintance with the health risks resulting from a poor diet.</td></tr>
<tr><td>Learning outcomes</td><td>1. Student is able to recall and define phytocomponents present in the human diet.
2. Student is able to explain the role of proper nutrition to maintain human health.
3. Student is able to evaluate the human diet in terms of its impact on health.</td></tr>
<tr><td>Assessment methods</td><td>Effect 1-3. Assessment of the presentation prepared by the student and assessment of the student's activity during lectures.</td></tr>
<tr><td>Prerequisites</td><td>Knowledge about the basics of human nutrition</td></tr>
<tr><td>Course content with delivery methods</td><td>Human civilization diseases such as coronary heart disease, tumors, metabolic disorders such as diabetes, obesity. The role of free radicals and oxidative stress in the pathogenesis of human inflammatory diseases. The impact of human diet and lifestyle on the risk of civilization diseases development. The role of individual phytocomponents such as dietary fiber, oligosaccharides, polyphenols, vitamins, sterols, lipids in a healthy human diet. Antioxidative and anti-inflammatory activity of phytochemicals. Natural phytoestrogens of legume seeds.</td></tr>
<tr><td>Basic reference materials</td><td>1. Human Nutrition from the Gastroenterologist's Perspective Lessons from Expo Milano 2015 EditorsEnzo Grossi Fabio Pace, Springer
2. Mattila-Sandholm T., Saarela M. Functional dairy products. Woodhead publishing limited. Cambridge, 2000</td></tr>
<tr><td>Other reference materials</td><td>1. Juskiewicz J, Jankowski J., Kosmala M., Zduńczyk Z., Słomiński B. A. , Zduńczyk P. (2016). The effects of dietary dried fruit pomaces on growth performance and gastrointestinal biochemistry of turkey poults. Journal of Animal Physiology and Animal Nutrition 100, 967–976.
2. Fotschki B, Juśkiewicz J, Jurgoński A, Kołodziejczyk K, Milala J, Kosmala M, Zduńczyk Z. (2016) Anthocyanins in Strawberry Polyphenolic Extract Enhance the Beneficial Effects of Diets with Fructooligosaccharides in the Rat Cecal Environment. PLoS ONE 11(2): e0149081.doi:10.1371/journal.pone.0149081.
3. Juśkiewicz J, Jurgoński A, Kołodziejczyk K, Kosmala M, Milala J, Zduńczyk Z, Fotschki B, Żary-Sikorska E. Blood Glucose Lowering Efficacy of Strawberry Extracts Rich in Ellagitannins with Different Degree of Polymerization in Rats. Pol. J. Food Nutr. Sci., 2016, Vol. 66, No. 2, pp. 0–0 DOI: 10.1515/pjfns-2016-0001.
4. Jankowski J. Juśkiewicz J., Zduńczyk P., Kosmala M., Zieliński H., Antoszkiewicz Z., Zduńczyk Z. Antioxidant status of blood and liver of turkeys fed diets enriched with polyunsaturated fatty acids and fruit pomaces as a source of polyphenols. Polish Journal of Veterinary Sciences Vol. 19, No. 1 (2016), 89–98</td></tr>
<tr><td>Average student workload</td><td>10 h</td></tr>
</table>

outside classroom	
Comments	
Last update	

<table>
<tr><td>Course code</td><td>CC4</td></tr>
<tr><td>Type and description</td><td>CC4 - core curriculum for food technology and nutrition</td></tr>
<tr><td>ECTS credit</td><td>1</td></tr>
<tr><td>Course name</td><td>Advances in fermented food and beverages I</td></tr>
<tr><td>Course name in Polish</td><td>Postępy w technologii żywności i napojów fermentowanych I</td></tr>
<tr><td>Language of instruction</td><td>English</td></tr>
<tr><td>Course level</td><td>8 PRK</td></tr>
<tr><td>Course coordinator</td><td>Dr hab. inż. Edyta Kordialik-Bogacka</td></tr>
<tr><td>Course instructors</td><td>Dr hab. inż. Anna Diowksz, dr hab. inż. Katarzyna Śliżewska, prof. PŁ, dr inż. Agnieszka Wilkowska, dr inż. Urszula Dziekońska</td></tr>
<tr><td>Delivery methods and course duration</td><td>
<table>
<tr><th></th><th>Lecture</th><th>Tutorials</th><th>Laboratory</th><th>Project</th><th>Seminar</th><th>Other</th><th>Total of teaching hours during semester</th></tr>
<tr><td>Contact hours</td><td>5</td><td></td><td>10</td><td></td><td></td><td>0</td><td>15</td></tr>
<tr><td>E-learning</td><td>No</td><td>No</td><td>No</td><td>No</td><td>No</td><td>No</td><td></td></tr>
<tr><td>Assessment criteria (weightage)</td><td>50,00</td><td></td><td>50,00</td><td></td><td></td><td>0,00</td><td></td></tr>
</table>
</td></tr>
<tr><td>Course objective</td><td>The aim of the course is to familiarize PhD students with modern applications in fermentation technology, including baking, dairy and alcoholic beverages technologies</td></tr>
<tr><td>Learning outcomes</td><td>After completing the course, a PhD student is able to:
1. list and describe innovative fermented products
2. list novel raw materials and additives and explain their technological role
3. describe potential modifications in technologies of fermented products
4. select and apply the appropriate analytical techniques
5. interpret and evaluate the results of analysis critically
6. organize work in a group, cooperate with members of the group, show responsibility for the entrusted range of studies, quality of own work</td></tr>
<tr><td>Assessment methods</td><td>Learning outcomes 1-3: written test.
Learning outcomes 4-6: laboratory reports, assessment of work, attitude and engagement in the classes.

Final assessment includes:
1. written test (80%)
2. laboratory reports and student activity (20%)</td></tr>
<tr><td>Prerequisites</td><td>Knowledge of biochemistry, microbiology and biotechnology</td></tr>
<tr><td>Course content with delivery methods</td><td>LECTURE
Presentation of innovations in fermented food and beverages production (bread, meat and milk products, beer, wine and spirits), including use of starters, probiotics, immobilized microorganisms, alternative raw materials, enzymes, biologically active substances and other additives.
LABORATORY
The programme covers microbiological problems, fermentation technologies, including starters, fermentation with immobilized cells.</td></tr>
<tr><td>Basic reference materials</td><td>Innovations in Technologies for Fermented Food and Beverage Industries. Editors: Sandeep Kumar Panda; Prathapkumar Halady Shetty, Springer, 1st edition, 2018</td></tr>
<tr><td>Other reference materials</td><td></td></tr>
<tr><td>Average student workload outside classroom</td><td>15 h</td></tr>
<tr><td>Comments</td><td></td></tr>
<tr><td>Last update</td><td></td></tr>
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<table>
<tr><td>Course code</td><td>CC5</td></tr>
<tr><td>Type and description</td><td>CC5 - core curriculum for food technology and nutrition</td></tr>
<tr><td>ECTS credit</td><td>1</td></tr>
<tr><td>Course name</td><td>Modern Trends In Food Technology II</td></tr>
<tr><td>Course name in Polish</td><td>Nowoczesne trendy w technologii żywności II</td></tr>
<tr><td>Language of instruction</td><td>English</td></tr>
<tr><td>Course level</td><td>8 PRK</td></tr>
<tr><td>Course coordinator</td><td>Dr hab. inż. Grażyna Budryn, prof. PŁ</td></tr>
<tr><td>Course instructors</td><td></td></tr>
<tr><td>Delivery methods and course duration</td><td>
<table>
<tr><th></th><th>Lecture</th><th>Tutorials</th><th>Laboratory</th><th>Project</th><th>Seminar</th><th>Other</th><th>Total of teaching hours during semester</th></tr>
<tr><td>Contact hours</td><td>5</td><td></td><td>10</td><td></td><td></td><td>0</td><td>15</td></tr>
<tr><td>E-learning</td><td>No</td><td>No</td><td>No</td><td>No</td><td>No</td><td>No</td><td></td></tr>
<tr><td>Assessment criteria (weightage)</td><td>60,00</td><td></td><td>40,00</td><td></td><td></td><td>0,00</td><td></td></tr>
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</td></tr>
<tr><td>Course objective</td><td>The aim of the course is to familiarize students with the latest trends on the food market, related to the production and distribution of food and the use of innovative processes.</td></tr>
<tr><td>Learning outcomes</td><td>After completing the course the student can:
1. Describe new technologies of processing, preservation and storage of food
2. Define food adulteration and methods to detect adulteration
3. Adjust the processing of food to the needs of the entrepreneur or consumer</td></tr>
<tr><td>Assessment methods</td><td>Learning outcomes 1-2: Written test of issues covering the content of the lecture.
The assessment criteria are: integration of knowledge, compatibility of answers with the subject of the question, use of the latest literature data, ability to justify the opinion.
The results of the test: 40%.
Learning outcome 3: Completion of laboratory exercises and laboratory report.
The assessment criteria are: active participation in laboratory classes, innovative approach and the use of knowledge acquired during lectures to complete the task, completeness of the report.
The assessment of the results of laboratory work and of the report: 60%.</td></tr>
<tr><td>Prerequisites</td><td>Basics of knowledge in the field food processing</td></tr>
<tr><td>Course content with delivery methods</td><td>Lecture:
1. Adulteration and authentication of food products
2. New technologies of food processing and preservation
Laboratory:
1. Innovative methods of food preservation
2. Preserving the high quality of food products using modern unit processes</td></tr>
<tr><td>Basic reference materials</td><td>1. Collective authorship edited by C. Leadley: "Innovation and Future Trends in Food Manufacturing and Supply Chain Technologies", Elsevier, 2016, Berlin
2. Collective authorshipedited by F. Contoer: "Advences in Dairy Products", Jonh Wiley & Sons Ltd, 2018, New York
3. Collective authorship edited by I. Aguilo-Aguayo, L. Plaza: "Innovative Technologies in Beverage Processing" John Wiley & Sons Ltd, 2017, New York
4. Collective authorship edited by D. Ghosh, S. Das, D. Bagchi, R.B. Smarta: "Innovation in Healthy and Functional Foods" CRC Press, 2012, Booca Raton
5. Collective authorship edited by Ö. Tokuşoğlu: "Food By-Product Based Functional Food Powders" CRC Press, 2018</td></tr>
<tr><td>Other reference materials</td><td>Scientific articles from international journals in the field of food and nutrition science and technology</td></tr>
<tr><td>Average student workload outside classroom</td><td>15 h</td></tr>
<tr><td>Comments</td><td></td></tr>
<tr><td>Last update</td><td></td></tr>
</table>

Course code	CC6
Type and description	CC6 - core curriculum for food technology and nutrition
ECTS credit	1
Course name	Biocatalysis
Course name in Polish	Biokataliza
Language of instruction	English
Course level	8 PRK
Course coordinator	Dr hab. inż. Aneta Białkowska
Course instructors	
Delivery methods and course duration	

	Lecture	Tutorials	Laboratory	Project	Seminar	Other	Total of teaching hours during semester
Contact hours	15					0	15
E-learning	No	No	No	No	No	No	
Assessment criteria (weightage)	100,00					0,00	

Course objective	The aim of the course is to familiarize students with the assumptions of applied biocatalysis, including: • modern methods of obtaining unique enzymes through highly efficient functional screening and sequential genomic and metagenomic libraries; • bioinformatic tools and molecular biology techniques used for the engineering of enzymatic proteins for selected features, especially useful for specific industrial applications • with the promiscuity of enzymes and engineering the environment of their reaction • the design of 'unnatural' enzymes and their use in the bio-processes • appropriate selection of enzymes, both native and improved for their use in specific biotechnologies
Learning outcomes	After completing the course, a PhD student is able to: 1. describe the methods of functional and sequential screening of genomic and metagenomic libraries in the search for specific enzymatic activities 2. describe bioinformatic tools and molecular biology techniques used for the engineering of enzymatic proteins for selected features, especially useful for specific industrial applications 3. define of enzyme promiscuity and give some examples 4. describe of reaction engineering for high reaction rate 5. describe of methods used for design unnatural proteins including non-proteinogenic amino acids and give some examples their application 6. argue the role of molecular biotechnology in biocatalysis
Assessment methods	Learning outcomes 1-6. Credits in writing
Prerequisites	Knowledge of chemistry, biochemistry, enzymology and molecular biology
Course content with delivery methods	1. Screening of unique enzymes. Functional and sequential screening of genomes and metagenoms from conventional and extreme environments. 2. Protein engineering. Sequence-structure relationship and function of enzymatic proteins. Mutagenesis rational design and directed evolution of enzymes. High-performance screening techniques based on the physical binding of the genotype to the phenotype. 3. Synthetic biology. Design of de novo enzymes based on known scaffolds in order to obtain catalytic proteins with new functions unknown so far. 4. Catalytic promiscuity of enzymes. Selection of enzymes with wide substrate specificity and their use in various reactions. Selection of reaction conditions, including reaction environment (water or unconventional environments: organic solvents, supercritical liquids, two-phase systems, gas environment, ionic liquids). 5. Potential of native and recombinant enzymes in various industrial processes and services.
Basic reference materials	1. Current developments in biotechnology and bioengineering (2017) Ed. Larroche Ch, Sanroman MA, Du G, Pandey A 2. Applied biocatalysis: from fundamental science to industrial application (2016). Ed. Hilterhaus L, Liese A, Kettling U, Antranikian G 3. Biocatalysis – a practical approach (2016). Ed. de Gonzalo G, Lavandera I
Other reference materials	
Average student workload outside classroom	15 h
Comments	
Last update	

Course code	CC7
Type and description	CC7 - core curriculum for food technology and nutrition
ECTS credit	1
Course name	Modern microbiological analysis in food industry
Course name in Polish	Nowoczesna analiza mikrobiologiczna w przemyśle spożywczym
Language of instruction	English
Course level	8 PRK
Course coordinator	dr hab. inż. Alina Kunicka-Styczyńska, prof. PŁ
Course instructors	dr hab. Katarzyna Rajkowska
Delivery methods and course duration	

	Lecture	Tutorials	Laboratory	Project	Seminar	Other	Total of teaching hours during semester
Contact hours	15					0	15
E-learning	No	No	No	No	No	No	
Assessment criteria (weightage)	40,00		60,00			0,00	

Course objective	The aim of the subject is a transfer of knowledge of modern technics in microbiological analysis applied in industrial practice of food and beverages production
Learning outcomes	After completing the subject a student: 1. can indicate the objectives and scope of the microbiological analysis in food production 2. is able to choose appropriate system of microbiological analysis to detect specific groups of microorganisms 3. applies instrumental analysis techniques used in microbiological analysis 4. learns independently in a targeted manner 5. demonstrates ability to work in a team
Assessment methods	Effects 1-2 – an open test Effect 3 - reports of laboratory activities Effects 4-5 – observation activities in the classroom Final assessment includes: - an open test result 60% - reports of laboratory activities 20% - activity in the classroom 20%
Prerequisites	Basic knowledge in general microbiology
Course content with delivery methods	LECTURE: Defining the aims of microbiological analysis in food production, and an indication of the modern, automated techniques to ensure fast and reliable assessment of the microbiological quality of the product. Criteria for the selection of techniques for continuous monitoring of the microbiological purity of the food and beverage production environment. An overview of the rules of operation and the identification of weaknesses and strengths of selected microbiological analysis systems designed for the use in the food industry. Systems designed to detect (Milliflex® Quantum system, EZ-FluoTM Rapid Detection System, TEMPO® system, HY-LITE® system) and microorganisms identification (API®, CHEMUMEX® technology, GENE-UP® platform) in food and environmental samples. LABORATORY: Activities in the form of workshops for performing microbiological analysis of foods and to determine the state of hygiene and identification of microorganisms from the selected abiotic surfaces using automated systems: 1. Rapid detection of microorganisms in food industry focusing on bioburden monitoring in a production environments. Milliflex® Quantum system (Merck) – combines industry-standard membrane filtration techniques with a rapid fluorescent staining method for quantitative detection of viable and culturable microorganisms in liquid samples 2. EZ-FluoTM Rapid Detection System (Merck) – fluorescent staining technique used in rapid detection and quantification of microbial contamination in samples of food and beverages 3. TEMPO® system (bioMerieux) for a rapid monitoring of microbiological quality control parameters in food and beverages products as well as a food production environment. The system enables to detect and enumerate both the saprophytic microorganisms as well as E. coli, Enterobacteriaceae, Staphylococcus aureus in food samples. 4. Hygiene monitoring in real production area by means of HY-LITE® system (Merck) – a rapid system for detection of microorganisms in production environment samples 5. CHEMUMEX® technology (bioMerieux) – a rapid detection of viable culturable and viable non-culturable microorganisms by fluorescent staining using flow cytometry and solid state laser scanning cytometry

	6. API® (bioMerieux) international standardized identification system for microorganisms – a reference international method for microorganisms identification 7. GENE-UP® platform (bioMerieux) for detection and identification of common pathogens if food industry e.g. Escherichia coli O157:H7 and Listeria spp. by molecular methods
Basic reference materials	1. Buszewski B., Rogowska A., Pomastowski P., Złoch M., Railean-Plugaru V. 2017. Identification of microorganisms by modern analytical techniques, Journal Of AOAC International 100, 6, 1607-1623 2. Pomeranz Y. 2013. Food Analysis: Theory and Practice, Springer
Other reference materials	
Average student workload outside classroom	15 h
Comments	
Last update	

<table>
<tr><td>Course code</td><td>CC8</td></tr>
<tr><td>Type and description</td><td>CC8 - core curriculum for food technology and nutrition</td></tr>
<tr><td>ECTS credit</td><td>1</td></tr>
<tr><td>Course name</td><td>Advances in fermented food and beverages II</td></tr>
<tr><td>Course name in Polish</td><td>Postępy w technologii żywności i napojów fermentowanych II</td></tr>
<tr><td>Language of instruction</td><td>English</td></tr>
<tr><td>Course level</td><td>8 PRK</td></tr>
<tr><td>Course coordinator</td><td>Dr hab. inż. Edyta Kordialik-Bogacka</td></tr>
<tr><td>Course instructors</td><td>Dr hab. inż. Anna Diowksz, dr hab. inż. Katarzyna Śliżewska, prof. PŁ, dr inż. Agnieszka Wilkowska, dr inż. Urszula Dziekońska</td></tr>
<tr><td>Delivery methods and course duration</td><td>
<table>
<tr><th></th><th>Lecture</th><th>Tutorials</th><th>Laboratory</th><th>Project</th><th>Seminar</th><th>Other</th><th>Total of teaching hours during semester</th></tr>
<tr><td>Contact hours</td><td></td><td></td><td></td><td>15</td><td></td><td>0</td><td>15</td></tr>
<tr><td>E-learning</td><td>No</td><td>No</td><td>No</td><td>No</td><td>No</td><td>No</td><td></td></tr>
<tr><td>Assessment criteria (weightage)</td><td></td><td></td><td></td><td>100,00</td><td></td><td>0,00</td><td></td></tr>
</table>
</td></tr>
<tr><td>Course objective</td><td>The aim of the course is to familiarize PhD students with modern applications in fermentation technology, including baking, dairy and alcoholic beverages technologies</td></tr>
<tr><td>Learning outcomes</td><td>After completing the course, a PhD student is able to:
1. describe innovative fermented products
2. discuss novel raw materials and additives and explain their technological role
3. describe potential modifications in technologies of fermented products
4. apply relevant knowledge to devise new fermented products
5. interpret and evaluate the results of analysis critically
6. organize work in a group, cooperate with members of the group, show responsibility for the entrusted range of studies, quality of own work</td></tr>
<tr><td>Assessment methods</td><td>Learning outcomes 1-5 are assessed by a written report, multimedia presentation, participation in discussion.
Learning outcome 6 is assessed by supervisor’s observation of student’s attitude and engagement in the classes, evaluation by members of the team.

Final assessment includes:
1. written report (30%)
2. multimedia presentation and participation in discussion (20%)
3. supervisor’s observation (30%)
4. assessment of members of the team (20%)</td></tr>
<tr><td>Prerequisites</td><td>Knowledge of fermented food and beverages</td></tr>
<tr><td>Course content with delivery methods</td><td>PROJECT
The project uses the method of Problem-based learning (PBL). Students identify what they need to learn and what resources they are going to use to solve a problem pertinent to production of fermented food and beverages. Students learn working cooperatively in groups to seek solutions to real world problems.</td></tr>
<tr><td>Basic reference materials</td><td>Innovations in Technologies for Fermented Food and Beverage Industries. Editors: Sandeep Kumar Panda; Prathapkumar Halady Shetty, Springer, 1st edition, 2018</td></tr>
<tr><td>Other reference materials</td><td></td></tr>
<tr><td>Average student workload outside classroom</td><td>15 h</td></tr>
<tr><td>Comments</td><td></td></tr>
<tr><td>Last update</td><td></td></tr>
</table>

Załącznik nr 12
do Programu Kształcenia w ISD PŁ –
ścieżka kształcenia w dyscyplinie
Nauki o zarządzaniu i jakości

TRAINING PROGRAM IN DISCIPLINE:
Management and Quality Sciences

1. Basic information

Domain: Social sciences
Discipline: Management and quality sciences
Degree awarded: PhD in Management and quality sciences
Program Coordinators:

Name: Dr hab. inż. Magdalena Grębosz-Krawczyk
Institute: Department of European Integration and International Marketing
Email: magdalena.grebosz@p.lodz.pl
Name: Dr hab. inż. Marek Matejun
Institute: Department of Management
Email: marek.matejun@p.lodz.pl

2. Lecturers

No	Name and surname	Title/degree	Website/ORCID
1.	Anna Adamik	dr hab.	0000-0002-6007-5675
2.	Robert Blażlak	dr	0000-0003-3673-7701
3.	Filip Chybalski	dr hab.	0000-0001-9555-8741
4.	Sylwia Flaszewska	dr	0000-0003-2022-5939
5.	Magdalena Grębosz-Krawczyk	dr hab. inż.	0000-0001-8339-2270
6.	Tomasz Jasiński	dr inż.	0000-0001-9367-0086
7.	Małgorzata Koszewska	dr hab.	0000-0002-8324-4937
8.	Edyta Marcinkiewicz	dr hab. inż.	0000-0002-2229-4084
9.	Marek Martin	dr inż.	0000-0001-7925-6399
10.	Marek Matejun	dr hab. inż.	0000-0003-4885-2344
11.	Michał Nowicki	dr	0000-0003-3307-5626
12.	Edyta Pietrzak	dr hab.	0000-0003-1878-7545
13.	Dagna Siuda	dr	0000-0002-9161-1354
14.	Maciej Soin	prof. dr hab.	0000-0003-2392-1286

15.	Iwona Staniec	dr inż.	0000-0002-5580-5450
16.	Robert Stanisławski	dr hab.	0000-0002-0845-8425
17.	Katarzyna Szymańska	dr	0000-0001-7435-5451
18.	Anna Walecka	dr	0000-0003-3297-8268
19.	Iwona Wojciechowska-Toruńska	dr	0000-0003-0550-7815
20.	Agnieszka Zakrzewska – Bielawska	dr hab. inż.	0000-0001-8182-3591

3. Training demand

The systemic changes occurring in the Polish and global economy, such as the inflow of foreign capital, the emergence of a large, small and medium enterprises, the development of new management concepts, growing environmental requirements, growing level of education as well as the aspirations of society, require the education of scientists comprehensively prepared to undertake international research in the discipline of management and quality sciences, as well as organizational and managerial functions at various levels of enterprises. Therefore, there is a need for education in the field of management, preparing for work in research and development units, in higher education institutions through the introduction of a candidate for research work using the latest achievements and scientific results in the field of doctoral studies selected by the candidate. A graduate, having obtained a doctorate, has not only extensive knowledge in the field of management and quality sciences, but also has the ability to set, analyze and propose solutions to complex problems and their synthetic description. These features allow him to flexibly adapt to taking up employments in various fields.

4. Detailed entry requirements

The formal requirement for candidates for studies is to have the master's diploma or an equivalent diploma. In addition, the candidate should demonstrate the predisposition to scientific and research work, the ability to work independently, the ability to acquire and apply knowledge from various fields, as well as the predispositions for objective analysis and evaluation of the own observations and collected research results.

5. Teaching methods

Lectures, tutorials, laboratories, projects, scientific seminars.

6. Graduate’s profile

The graduate of ISD in the discipline of management and quality sciences is a person fully skilled in terms of the state of scientific knowledge in the area of organization and management. Developing one’s scientific and professional career – is able to improve the research and practical application of these areas of knowledge with particular emphasis on the problems of managing all the basic areas of the modern enterprise. In the course of studies, the graduate gains knowledge related to the most advanced methods, techniques, trends and tendencies under the supervision of lecturers from local and foreign centers. The graduates are directed to issues related to individual subject of the

doctoral theses. Realization of the research projects prepares young scientists for tasks related to creating their own research teams, managing R&D departments in enterprises, creating international consortia, development of products, processes and services, as well as creating independent entities such as spin off or start up. In addition, they gain the knowledge needed to take up managerial functions at all levels within the company regardless of its size and character, both in large enterprises and the SME sector.

The graduate is able to actively use of knowledge acquired during studies and apply it in research area, as well as in a business practice, to make critical analysis and evaluation of phenomena of the modern management, diagnoses and assesses managerial problems using a clear and precise specialist language.

7. Training plan

Semester 1									
No.	Abbreviation	Course name							ECTS
			L	T	L	P	S	Σ	
1	E	Entrepreneurship	15					15	1
2	CC1	Management concepts - in theory	15					15	1
3	CC2	Economics 1	15					15	1
Total								45	3
Semester 2									
No.	Abbreviation	Course name							ECTS
			L	T	L	P	S	Σ	
1	CC3	Management concepts - in practice		5		10		15	1
2	CC4	Economics 2	15					15	1
Total								30	2
Semester 3									
No.	Abbreviation	Course name							ECTS
			L	T	L	P	S	Σ	
1	CC5	Research methodology in management and quality sciences 1				15		15	1
2	CC6	Quantitative methods in social sciences 1	15					15	1
Total								30	2
Semester 4									
1	CC7	Research methodology in management and quality sciences 2		15				15	1
2	CC8	Quantitative methods in social sciences 2			15			15	1
Total								30	2
TOTAL								**135**	**9**

<table>
<tr><td>Course code</td><td>CC1</td></tr>
<tr><td>Type and description</td><td>CC - curriculum for discipline management and quality sciences</td></tr>
<tr><td>ECTS credit</td><td>1</td></tr>
<tr><td>Course name</td><td>Management concepts- in theory</td></tr>
<tr><td>Course name in Polish</td><td>Koncepcje zarządzania – w teorii</td></tr>
<tr><td>Language of instruction</td><td>English</td></tr>
<tr><td>Course level</td><td>8 PRK</td></tr>
<tr><td>Course coordinator</td><td>dr hab. Anna Adamik (0000-0002-6007-5675)</td></tr>
<tr><td>Course instructors</td><td>dr hab. Anna Adamik (0000-0002-6007-5675)
dr hab. inż. Marek Matejun (0000-0003-4885-2344)
dr hab. Agnieszka Zakrzewska–Bielawska (0000-0001-8182-3591)
dr Anna Walecka (0000-0003-3297-8268)
dr Katarzyna Szymańska
dr Sylwia Flaszewska (0000-0003-2022-5939)
dr Michał Nowicki (0000-0003-3307-5626)</td></tr>
<tr><td>Delivery methods and course duration</td><td>
<table>
<tr><th></th><th>Lecture</th><th>Tutorials</th><th>Laboratory</th><th>Project</th><th>Seminar</th><th>Other</th><th>Total of teaching hours during semester</th></tr>
<tr><td>Contact hours</td><td>15</td><td></td><td></td><td></td><td></td><td>0</td><td>15</td></tr>
<tr><td>E-learning</td><td>No</td><td>No</td><td>No</td><td>No</td><td>No</td><td>No</td><td></td></tr>
<tr><td>Assessment criteria (weightage)</td><td>1,0</td><td></td><td></td><td></td><td></td><td>0,00</td><td>1</td></tr>
</table>
</td></tr>
<tr><td>Course objective</td><td>The goal of the subject
1. The aim of the course is to enable students to acquire knowledge in the field of implementation conditions (implementation environment) of contemporary and modern management concepts
2. The aim of the course is to enable students to acquire knowledge in the field of specificity of selected contemporary and modern management concepts</td></tr>
<tr><td>Learning outcomes</td><td>A PhD student after completing the course can:
1. characterize the contemporary environment of implementing the concept of management (the environment and the interior of the organization, the process of managing organizations) (W1, W2)
2. describe the theoretical basis of contemporary and modern concepts of management (conditions, principles, effects) (U1)
3. identify and interpret phenomena related to the implementation of contemporary and modern management concepts (opportunities and threats) (U1, K1)</td></tr>
<tr><td>Assessment methods</td><td>Verification methods of learning outcomes
effects 1 -3- written exam</td></tr>
<tr><td>Prerequisites</td><td>None</td></tr>
<tr><td>Course content with delivery methods</td><td>LECTURE
1-2. Context of the implementation of contemporary and modern management concepts: The specificity of the environment and the internal environment of contemporary organizations (high speed environment, the age of Industry 4.0, the potential for competitiveness and the dynamics of the management process)
3-4. Overview of contemporary management concepts
Business Process Reengineering (BPR), Lean Management, Lean Production (Manufacturing), Total Quality Management (TQM), Just In Time, Marketing, Logistics, Controlling, Human Capital Management, Benchmarking, Outsourcing, project management, servitization
5-6. Review of modern management concepts
Network thinking, co-creation, virtual organization, social responsibility, paradox management, trust management, knowledge management, knowledge and process mapping, design management, diversity management</td></tr>
<tr><td>Basic reference</td><td>1.Lecturer's material</td></tr>
</table>

materials	2.Certo S.C., Certo S.T.: Modern Management: Concepts and Skills, Global Edition, Pearson Education Limited, 2015. 3. Ermine J.L.: Knowledge Management: The Creative Loop, Volume 5, 30 March 2018. 4. Khosrow-Pour M.: Entrepreneurship, Collaboration, and Innovation in the Modern Business Era, 2018.
Other reference materials	Alkhafaji A.F.: Strategic Management: Formulation, Implementation, and Control in a Dynamic Environment, 2013.
Average student workload outside classroom	10 h
Comments	None
Last update	07.04.2019

<table>
<tr><td>Course code</td><td>CC2</td></tr>
<tr><td>Type and description</td><td>CC - curriculum for discipline management and quality sciences</td></tr>
<tr><td>ECTS credit</td><td>1</td></tr>
<tr><td>Course name</td><td>Economics 1</td></tr>
<tr><td>Course name in Polish</td><td>Ekonomia 1</td></tr>
<tr><td>Language of instruction</td><td>English</td></tr>
<tr><td>Course level</td><td>8 PRK</td></tr>
<tr><td>Course coordinator</td><td>dr inż. Tomasz Jasiński (0000-0001-9367-0086)</td></tr>
<tr><td>Course instructors</td><td>dr inż. Tomasz Jasiński (0000-0001-9367-0086)
dr inż. Marek Martin (000-0001-7925-6399)</td></tr>
<tr><td>Delivery methods and course duration</td><td>
<table>
<tr><th></th><th>Lecture</th><th>Tutorials</th><th>Laboratory</th><th>Project</th><th>Seminar</th><th>Other</th><th>Total of teaching hours during semester</th></tr>
<tr><td>Contact hours</td><td>15</td><td></td><td></td><td></td><td></td><td>0</td><td>15</td></tr>
<tr><td>E-learning</td><td>No</td><td>No</td><td>No</td><td>No</td><td>No</td><td>No</td><td></td></tr>
<tr><td>Assessment criteria (weightage)</td><td>1,0</td><td></td><td></td><td></td><td></td><td>0,00</td><td>1</td></tr>
</table>
</td></tr>
<tr><td>Course objective</td><td>The goal of the subject
1. Awareness of theoretical foundations of micro and macroeconomics
2. Development of economic data usage skills</td></tr>
<tr><td>Learning outcomes</td><td>A PhD student after completing the course can:
1. characterize the contemporary economic concepts (W1, K1)
2. identify and interpret economic phenomena (U1)</td></tr>
<tr><td>Assessment methods</td><td>Verification methods of learning outcomes
effects 1-2 - written test</td></tr>
<tr><td>Prerequisites</td><td>None</td></tr>
<tr><td>Course content with delivery methods</td><td>LECTURE
1. The subject and basic concepts of economics
2. Methods and tools of economic research
3. Main trends in contemporary economic thought
4. Market - basic concepts and interdependencies
5. The fundamentals of consumer theory.
6. National income account
7. The role of the state in the economy
8. Money and banking system
9. The economic cycle
10. Unemployment
11. Inflation</td></tr>
<tr><td>Basic reference materials</td><td>1.Lecturer's material
2. Peter Smith , David K.H. Begg, Economics Workbook Paperback, McGraw-Hill Publishing Co, Jun 1994.
3. Mark P. Taylor and N. Gregory Mankiw, Economics, Cengage Learning, 28 Mar 2014.</td></tr>
<tr><td>Other reference materials</td><td>-</td></tr>
<tr><td>Average student workload outside classroom</td><td>10 h</td></tr>
<tr><td>Comments</td><td>None</td></tr>
<tr><td>Last update</td><td>10.04.2019</td></tr>
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<tr><td>Course code</td><td>CC3</td></tr>
<tr><td>Type and description</td><td>CC - curriculum for discipline management and quality sciences</td></tr>
<tr><td>ECTS credit</td><td>1</td></tr>
<tr><td>Course name</td><td>Management concepts- in practice</td></tr>
<tr><td>Course name in Polish</td><td>Koncepcje zarządzania - w praktyce</td></tr>
<tr><td>Language of instruction</td><td>English</td></tr>
<tr><td>Course level</td><td>8 PRK</td></tr>
<tr><td>Course coordinator</td><td>dr hab. Anna Adamik (0000-0002-6007-5675)</td></tr>
<tr><td>Course instructors</td><td>dr hab. Anna Adamik (0000-0002-6007-5675)
dr hab. inż. Marek Matejun (0000-0003-4885-2344)
dr hab. Agnieszka Zakrzewska–Bielawska (0000-0001-8182-3591)
dr Anna Walecka (0000-0003-3297-8268)
dr Katarzyna Szymańska
dr Sylwia Flaszewska (0000-0003-2022-5939)
dr Michał Nowicki (0000-0003-3307-5626)</td></tr>
<tr><td>Delivery methods and course duration</td><td>
<table>
<tr><th></th><th>Lecture</th><th>Tutorials</th><th>Laboratory</th><th>Project</th><th>Seminar</th><th>Other</th><th>Total of teaching hours during semester</th></tr>
<tr><td>Contact hours</td><td>0</td><td>5</td><td></td><td>10</td><td></td><td>0</td><td>15</td></tr>
<tr><td>E-learning</td><td>No</td><td>No</td><td>No</td><td>No</td><td>No</td><td>No</td><td></td></tr>
<tr><td>Assessment criteria (weightage)</td><td>0,00</td><td>0,25</td><td></td><td>0,75</td><td></td><td>0,00</td><td>1</td></tr>
</table>
</td></tr>
<tr><td>Course objective</td><td>The goal of the subject
1. The aim of the course is to enable students to acquire practical skills to assess the possibilities and consequences of implementing modern and modern management concepts in organizations
2. The aim of the course is to enable students to acquire practical skills in designing the implementation processes of modern and modern management concepts for the organization</td></tr>
<tr><td>Learning outcomes</td><td>A PhD student after completing the course can:
1. identify and evaluate the conditions for the implementation of modern and modern concepts of management in selected organizations (on practical examples) (U1, U2)
2. identify and describe the advantages and disadvantages of practical implementation in selected organizations of modern and modern management concepts (K1, K2)
3. design processes related to the implementation of modern management concepts into selected organizations (U4, K1)</td></tr>
<tr><td>Assessment methods</td><td>Verification methods of learning outcomes
effects 1. - discussion
effect 2 - presentation of the PBL project
effect 3 - presentation of the PBL project
The final grade consists of:
The result of the evaluation of activity in the discussion (20%) and the presentation of the PBL project (80%)</td></tr>
<tr><td>Prerequisites</td><td>Realizing the effects assigned to the subject Management concepts – in theory</td></tr>
<tr><td>Course content with delivery methods</td><td>exercises
1-2. Practice of applying modern management concepts in various industries (problems and benefits of implementation) - workshops with practitioners
3-6 PBL project
7. Presentation of project works</td></tr>
<tr><td>Basic reference materials</td><td>1.Lecturer's material.
2.Certo S.C., Certo S.T.:Modern Management: Concepts and Skills, Global Edition, Pearson Education Limited, 2015.
3. Ermine J.L.: Knowledge Management: The Creative Loop, Volume 5, 30 March 2018.
4. Khosrow-Pour M.: Entrepreneurship, Collaboration, and Innovation in the Modern Business Era, 2018.
5. Alkhafaji A.F.: Strategic Management: Formulation, Implementation, and Control in a Dynamic Environment, 2013</td></tr>
<tr><td>Other reference materials</td><td>1.Krajcik, J.S., Czerniak, C.M.: Teaching Science in Elementary and Middle School: A Project-Based Learning Approach, 2018.
2.Barell J.F.: Problem-Based Learning : An Inquiry Approach, SAGE Publications Inc., 2007.</td></tr>
</table>

Average student workload outside classroom	15 h
Comments	None
Last update	07.04.2019

Course code	CC4
Type and description	CC - curriculum for discipline management and quality sciences
ECTS credit	1
Course name	**Economics 2**
Course name in Polish	**Ekonomia 2**
Language of instruction	English
Course level	8 PRK
Course coordinator	**dr inż. Marek Martin (000-0001-7925-6399)**
Course instructors	**dr inż. Tomasz Jasiński (0000-0001-9367-0086)** **dr inż. Marek Martin (000-0001-7925-6399)**
Delivery methods and course duration	

	Lecture	Tutorials	Laboratory	Project	Seminar	Other	Total of teaching hours during semester
Contact hours	15					0	15
E-learning	No	No	No	No	No	No	
Assessment criteria (weightage)	1,0					0,00	1

Course objective	The goal of the subject 1. Familiarize with the fundamentals of economic aspects of managerial decision-making 2. Development of economic analysis skills
Learning outcomes	A PhD student after completing the course can: 1. characterize economic aspects of managerial decision-making (W1, K1) 2. interpret results of economic analysis (U1)
Assessment methods	Verification methods of learning outcomes effects 1-2 - written test
Prerequisites	None
Course content with delivery methods	LECTURE 1. The economic fundamentals of enterprise theory 2. Making managerial decisions 3. Basic concepts and tools for economic analysis 4. Demand analysis and optimal pricing policy 5. Production decisions 6. Cost analysis
Basic reference materials	1.Lecturer's material 2. Samuelson W.F., Marks S.G., Ekonomia menedżerska, PWE, Warszawa 2009. 3. Milewski R., Elementarne zagadnienia ekonomii, Wydawnictwo naukowe PWN S.A., Warszawa 2018.
Other reference materials	-
Average student workload outside classroom	10 h
Comments	None
Last update	10.04.2019

<table>
<tr><td>Course code</td><td>CC5</td></tr>
<tr><td>Type and description</td><td>CC – program framework for discipline management and quality sciences</td></tr>
<tr><td>ECTS credit</td><td>1</td></tr>
<tr><td>Course name</td><td>Research methodology in management and quality sciences – part 1</td></tr>
<tr><td>Course name in Polish</td><td>Metodologia badań w naukach o zarządzaniu i jakości – część 1</td></tr>
<tr><td>Language of instruction</td><td>English</td></tr>
<tr><td>Course level</td><td>8 PRK</td></tr>
<tr><td>Course coordinator</td><td>Dr hab. inż. Agnieszka Zakrzewska – Bielawska, prof. PŁ (0000-0001-8182-3591)</td></tr>
<tr><td>Course instructors</td><td>Dr hab. Anna Adamik (O0000-0002-6007-5675)
Dr hab. inż. Magdalena Gręposz-Krawczyk (0000-0001-8339-2270)
Dr hab. inż. Marek Matejun, prof. PŁ (0000-0003-4885-2344)</td></tr>
<tr><td>Delivery methods and course duration</td><td>
<table>
<tr><th></th><th>Lecture</th><th>Tutorials</th><th>Laboratory</th><th>Project</th><th>Seminar</th><th>Other</th><th>Total of teaching hours during semester</th></tr>
<tr><td>Contact hours</td><td>0</td><td>0</td><td>0</td><td>15</td><td>0</td><td>0</td><td>15</td></tr>
<tr><td>E-learning</td><td>No</td><td>No</td><td>No</td><td>No</td><td>No</td><td>No</td><td></td></tr>
<tr><td>Assessment criteria (weightage)</td><td>0</td><td>0</td><td>0</td><td>1</td><td>0</td><td>0</td><td></td></tr>
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</td></tr>
<tr><td>Course objective</td><td>1. To enable acquiring knowledge and skills in searching and formulating research problems in social sciences, especially in the management and quality sciences</td></tr>
<tr><td>Learning outcomes</td><td>After completing the course, PhD-student is able to:
1. define cognitive gaps in relation to a specific area of social sciences - outcomes W1, U1, K1
2. formulate a research problem, put forward hypotheses and research questions - outcomes W1, U1, U2, K1
3. select and apply the discussed methods of literature review - outcomes W1, U1, U2, U3, K1</td></tr>
<tr><td>Assessment methods</td><td>Verification methods of learning outcomes
outcomes 1 - 3 - project
Final grade – 100% project</td></tr>
<tr><td>Prerequisites</td><td>Not applicable</td></tr>
<tr><td>Course content with delivery methods</td><td>COMPUTER LABORATORY
1. Searching for cognitive gaps
2. Principles of formulating research problems, goals, hypotheses and research questions
3. Scientific databases and their resources
4. Method of analysis and criticism of the literature
5. Methodology of systematic literature review
6. Meta-analysis</td></tr>
<tr><td>Basic reference materials</td><td>1. Booth A., Sutton A., Papaioannou D., Systematic Approaches to a Successful Literature Review, Sage Publications Ltd, London 2016
2. Jesson J., Matheson L., Lacey F.M., Doing Your Literature Review: Traditional and Systematic Techniques, Sage Publications Ltd, London 2011
3. Saunders M., Lewis P., Thornhill A., Research Methods for Business Students, Pearson Education Limited, Edinburgh 2009.</td></tr>
<tr><td>Other reference materials</td><td>1. Bryman A, Bell E., Business Research Methods, Oxford University Press, Oxford 2011.
2. Kumar R., Research Methodology. A step-by-step Guide for Beginners, Sage Publications Ltd, London 2011.
3. Czakon W. (red.), Podstawy metodologii badań w naukach o zarządzaniu, Oficyna a Wolters Kluwer business, Warszawa 2015.</td></tr>
<tr><td>Average student workload outside classroom</td><td>20h</td></tr>
<tr><td>Comments</td><td>-</td></tr>
<tr><td>Last update</td><td>10.04.2019</td></tr>
</table>

<table>
<tr><td>Course code</td><td>CC6</td></tr>
<tr><td>Type and description</td><td>CC – program framework for discipline „management and quality sciences”</td></tr>
<tr><td>ECTS credit</td><td>1</td></tr>
<tr><td>Course name</td><td>Quantitative methods in social sciences 1</td></tr>
<tr><td>Course name in Polish</td><td>Metody ilościowe w naukach społecznych 1</td></tr>
<tr><td>Language of instruction</td><td>English</td></tr>
<tr><td>Course level</td><td>8 PRK</td></tr>
<tr><td>Course coordinator</td><td>Dr hab. Filip Chybalski, prof. PŁ (0000-0001-9555-8741)</td></tr>
<tr><td>Course instructors</td><td>Dr inż. Edyta Marcinkiewicz (0000-0002-2229-4084)
Dr inż. Iwona Staniec (0000-0002-5580-5450)</td></tr>
<tr><td>Delivery methods and course duration</td><td>
<table>
<tr><th></th><th>Lecture</th><th>Tutorials</th><th>Laboratory</th><th>Project</th><th>Seminar</th><th>Other</th><th>Total of teaching hours during semester</th></tr>
<tr><td>Contact hours</td><td>15</td><td></td><td></td><td></td><td></td><td>0</td><td>15</td></tr>
<tr><td>E-learning</td><td>No</td><td>No</td><td>No</td><td>No</td><td>No</td><td>No</td><td></td></tr>
<tr><td>Assessment criteria (weightage)</td><td>1,00</td><td></td><td></td><td></td><td></td><td>0,00</td><td></td></tr>
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</td></tr>
<tr><td>Course objective</td><td>To enable gaining knowledge on the selection and application of quantitative methods of data analysis</td></tr>
<tr><td>Learning outcomes</td><td>After completing the course, PhD-student can:
1. define selected notions of quantitative methods – outcomes W1, U1, U2
2. select and apply quantitative methods discussed to the analysis of social phenomena – outcomes W1, U1 - U3, K1</td></tr>
<tr><td>Assessment methods</td><td>Outcomes 1 and 2: written exam
Final grade: 100% written exam</td></tr>
<tr><td>Prerequisites</td><td>Not applicable</td></tr>
<tr><td>Course content with delivery methods</td><td>1. Basic terminology of quantitative methods
2. Organization of statistical research
3. Measures characterizing the structure of population
4. Correlation analysis
5. Dynamics analysis
6. Methods of inferential statistics
7. Regression analysis and forecasting
8. Other selected quantitative methods and their application
Analiza regresji</td></tr>
<tr><td>Basic reference materials</td><td>1. Lecturer’s materials
2. Aczel A.: Complete Business Statistics, Wohl Publishing, Morristown, 2012.
3. Stine R., Foster D., Statistics for Business, Pearson Education Limited, Essex, 2014.</td></tr>
<tr><td>Other reference materials</td><td>1. Baltagi B.H., Econometric analysis of panel data, Wiley, Chichester, 2013.
2. Wooldridge J.M., Econometric analysis of cross section and panel data, The MIT Press, Cambridge, London, 2010.
3. Makridakis S., Wheelwright S.C., Hyndman R.J., Forecasting, John Wiley & Sons, Hoboken, 1998.</td></tr>
<tr><td>Average student workload outside classroom</td><td>10h</td></tr>
<tr><td>Comments</td><td>-</td></tr>
<tr><td>Last update</td><td>10.04.2019</td></tr>
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<table>
<tr><td>Course code</td><td>CC7</td></tr>
<tr><td>Type and description</td><td>CC – program framework for discipline „management and quality sciences”</td></tr>
<tr><td>ECTS credit</td><td>1</td></tr>
<tr><td>Course name</td><td>Research methodology in management and quality sciences – part 2</td></tr>
<tr><td>Course name in Polish</td><td>Metodologia badań w naukach o zarządzaniu i jakości – część 2</td></tr>
<tr><td>Language of instruction</td><td>English</td></tr>
<tr><td>Course level</td><td>8 PRK</td></tr>
<tr><td>Course coordinator</td><td>Dr hab. inż. Agnieszka Zakrzewska – Bielawska, prof. PŁ (0000-0001-8182-3591)</td></tr>
<tr><td>Course instructors</td><td>Dr hab. Anna Adamik (0000-0002-6007-5675)
Dr hab. inż. Magdalena Grębosz-Krawczyk (0000-0001-8339-2270)
Dr hab. inż. Marek Matejun, prof. PŁ (0000-0003-4885-2344)</td></tr>
<tr><td>Delivery methods and course duration</td><td>
<table>
<tr><th></th><th>Lecture</th><th>Tutorials</th><th>Laboratory</th><th>Project</th><th>Seminar</th><th>Other</th><th>Total of teaching hours during semester</th></tr>
<tr><td>Contact hours</td><td>0</td><td>15</td><td>0</td><td>0</td><td>0</td><td>0</td><td>15</td></tr>
<tr><td>E-learning</td><td>No</td><td>No</td><td>No</td><td>No</td><td>No</td><td>No</td><td></td></tr>
<tr><td>Assessment criteria (weightage)</td><td>0</td><td>1</td><td>0</td><td>0</td><td>0</td><td>0</td><td></td></tr>
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<tr><td>Course objective</td><td>1. Familiarizing PhD-students with the rules of research methodology in social sciences, especially in the management and quality sciences.
2. Familiarizing PhD-students with quantitative and qualitative research methods, techniques and tools.
3. Formation the skills for providing scientific research in the field of management and quality sciences.</td></tr>
<tr><td>Learning outcomes</td><td>After completing the course, PhD-student is able to:
1. prepare a research procedure for a specific problem in the field of management and quality sciences - outcomes W1, U1, K1
2. select adequate quantitative and qualitative research methods - outcomes W1, U2, U3
3. develop research results and draw conclusions from them - outcomes W1, U2, U3, K1</td></tr>
<tr><td>Assessment methods</td><td>Verification methods of learning outcomes
outcomes 1 and 2 - written test
outcomes 2 and 3 – presentation of the chosen method of social research and results of pilot studies with its application
The final grade consists of:
The result of the written test - 40%
Presentation of the chosen method of social research - 40%
Presentation of pilot research results - 20%</td></tr>
<tr><td>Prerequisites</td><td>Knowledge of the basic literature in the field of management and quality sciences</td></tr>
<tr><td>Course content with delivery methods</td><td>TUTORIALS
1. Epistemology and methodology of scientific research
2. Methodological rigor
3. Methods, techniques, tools and research procedures in social sciences. Methodological polymorphism and triangulation of research methods.
4. Stages of research in modern science about management and quality.
5. Quantitative methods in social sciences
6. Qualitative methods in social sciences
7. Development of research results and rules for inferencing in the discipline of management and quality sciences</td></tr>
<tr><td>Basic reference materials</td><td>1. Kumar R., Research Methodology. A step-by-step Guide for Beginners, Sage Publications Ltd, London 2011.
2. Bryman A, Bell E., Business Research Methods, Oxford University Press, Oxford 2011.
3. Saunders M., Lewis P., Thornhill A., Research Methods for Business Students, Pearson Education Limited, Edinburgh 2009.</td></tr>
<tr><td>Other reference materials</td><td>1. Khan J.A., Research Methodology, APH Publishing Corporation, New Delhi 2011.
2. Bergh D.D., Ketchen D.J. (eds.), Research Methodology in Strategy and Management,</td></tr>
</table>

	Emerald Group Publishing Limited, UK 2009. 3. Czakon W. (red.), Podstawy metodologii badań w naukach o zarządzaniu, Oficyna a Wolters Kluwer business, Warszawa 2015.
Average student workload outside classroom	20h
Comments	-
Last update	10.04.2019

<table>
<tr><td>Course code</td><td>CC8</td></tr>
<tr><td>Type and description</td><td>CC – program framework for discipline „management and quality sciences”</td></tr>
<tr><td>ECTS credit</td><td>1</td></tr>
<tr><td>Course name</td><td>Quantitative methods in social sciences II</td></tr>
<tr><td>Course name in Polish</td><td>Metody ilościowe w naukach społecznych II</td></tr>
<tr><td>Language of instruction</td><td>English</td></tr>
<tr><td>Course level</td><td>8 PRK</td></tr>
<tr><td>Course coordinator</td><td>Dr hab. Filip Chybalski, prof. PŁ (0000-0001-9555-8741)</td></tr>
<tr><td>Course instructors</td><td>Dr inż. Edyta Marcinkiewicz (0000-0002-2229-4084)
Dr inż. Iwona Staniec (0000-0002-5580-5450)</td></tr>
<tr><td>Delivery methods and course duration</td><td>
<table>
<tr><th></th><th>Lecture</th><th>Tutorials</th><th>Laboratory</th><th>Project</th><th>Seminar</th><th>Other</th><th>Total of teaching hours during semester</th></tr>
<tr><td>Contact hours</td><td></td><td></td><td>15</td><td></td><td></td><td>0</td><td>15</td></tr>
<tr><td>E-learning</td><td>No</td><td>No</td><td>No</td><td>No</td><td>No</td><td>No</td><td></td></tr>
<tr><td>Assessment criteria (weightage)</td><td></td><td></td><td>1,00</td><td></td><td></td><td>0,00</td><td></td></tr>
</table>
</td></tr>
<tr><td>Course objective</td><td>To enable gaining skills in the application of computer software in quantitative analyses</td></tr>
<tr><td>Learning outcomes</td><td>After completing the course, PhD-student can:
1. select the quantitative methods discussed to the analysis of social phenomena – outcomes W1, U1 - U3, K1
2. apply quantitative methods discussed to the analysis of social phenomena with the use of computer software – outcomes U1-U3, K1.</td></tr>
<tr><td>Assessment methods</td><td>Outcomes 1 and 2: project
Final grade – 100% project</td></tr>
<tr><td>Prerequisites</td><td>Not applicable</td></tr>
<tr><td>Course content with delivery methods</td><td>1. Data sources
2. Data coding
3. Graphical presentation of data
4. Data analysis with methods of descriptive statistics
5. Data analysis with methods of inferential statistics
6. Correlation and regression</td></tr>
<tr><td>Basic reference materials</td><td>1. Lecturer’s materials
2. Aczel A.: Complete Business Statistics, Wohl Publishing, Morristown, 2012.
3. Stine R., Foster D., Statistics for Business, Pearson Education Limited, Essex, 2014.</td></tr>
<tr><td>Other reference materials</td><td>1. Heeringa S., West B., Berglund P., Applied Survey Data Analysis, CRC Press, Boca Raton, 2017.</td></tr>
<tr><td>Average student workload outside classroom</td><td>10h.</td></tr>
<tr><td>Comments</td><td>-</td></tr>
<tr><td>Last update</td><td>10.04.2019</td></tr>
</table>

Entrepreneurship

Course Coordinator:
Name: Julia Skrzypkowska
Institute/Department/ Entity etc.: Center for Cooperation with the Economy, Innovation and Technology Transfer
Email: julia.skrzypkowska@p.lodz.pl

No	Subcategory	Subject	Learning methods						Assessment method	ECTS	Code	Semester Winter/summer
			L	T	L	P	S	Σ				
1	E	Entrepreneurship	5			10		15	Effects: W2, U1, K2 – Project presentation (Business Model Canvas, Process Design Thinking) The final assessment consists of: Project presentation - 100%	1		Winter semester

Type and description	E
Course name	Entrepreneurship
Course name in Polish	Przedsiębiorczość
Language of instruction	English
Course coordinator and academic teachers	Coordinator - mgr Julia Skrzypkowska Academic teachers: mgr Julia Skrzypkowska mgr Grzegorz Kierner mgr Monika Kasieczka - Burnecka
Form of classes and number of teaching hours	
Course organisation and content	**Objectives:** 1. The course objective is to provide a possibility of gaining knowledge in conducting scientific activity and in the context of transferring the achievements to the economic and social sectors.

	Lecture	Tutorials	Laboratory	Project	Seminar	Others	Total
Contact hours	5	0	0	10	0	0	15
E-learning	no	no	no	no	no	no	-
Assessment criteria (weightage)	50%	0,00	0,00	50%	0,00	0,00	-

	2. The course objective is to give a possibility of acquiring skills concerning entrepreneurial competences within the conducted scientific activity. 3. The course objective is to enable gaining knowledge about a possibility of commercialization of the obtained scientific results in the disciplines and the areas with business potential, taking into consideration institutions and support programs for entrepreneurship and innovation. **Content:** Module 1 1. Introduction of the subject area of academic entrepreneurship 2. Innovation – definition, frames and scaling 3. Technology transfer and Intellectual Property protection Module 2 (workshop module with the use of the Design Thinking technique) 4. Development of the entrepreneurial competences: orientation to the customer 5. Development of the entrepreneurial competences: orientation to the problem 6. Development of the entrepreneurial competences: orientation to the solution 7. Presentation results of model 2 Module 3 (a required break after the previous module – about 3 weeks) 8. Identification of the areas with a business potential, postgraduates' presentations Module 4 9. Market analyses 10. Business model 11. Business planning 12. Budget planning 13. Forms of financing own business and commercialization results of activity in disciplines. 14. Institutions and support programs for entrepreneurship and innovation. Module 5 15. Team building
Assessment methods	Effects W2, U1, K2 – Project presentation (Business Model Canvas, Process Design Thinking) The final assessment consists of: Project presentation - 100%
Average student workload outside classroom	10h
Literature	Raport "Future Work Skills 2020" Change by Design, Brown Tim Business Model Generation, Osterwalder Alexander Brand Thinking and Other Noble Pursuits, Debbie Millman What Great Brands Do: The Seven Brand-Building Principles that Separate the Best from the Rest, Denise Lee Yohn Following: Learn to Make Millions in Up or Down Markets (Paperback), Michael W. Covel Thinking Fast and Slow, Daniel Kahneman's, The Lean Startup: How Today's Entrepreneurs Use Continuous Innovation to Create Radically Successful Businesses, Eric Ries Academic Entrepreneurship: Time for a Rethink?
Comments	None
Last update	29.04.2019