Uchwała Nr 6/2022
Senatu Politechniki Łódzkiej
z dnia 23 lutego 2022 r.

w sprawie ustalenia programu kształcenia
w Interdyscyplinarnej Szkole Doktorskiej Politechniki Łódzkiej

*(Tekst jednolity ze zmianami wprowadzonymi Uchwałą Nr 11/2023)*

Na podstawie art. 28 ust. 1 pkt 12, art. 200 ust. 3 i art. 201 ust. 4 ustawy z dnia 20 lipca 2018 r. – Prawo o szkolnictwie wyższym i nauce (t.j. Dz. U. z 2022 r. poz. 574, z późn. zm.) uchwala się, co następuje:

§ 1

Ustala się program kształcenia w Interdyscyplinarnej Szkole Doktorskiej Politechniki Łódzkiej, stanowiący załącznik do uchwały, i stosuje od roku akademickiego 2022/2023.

§ 2

Uchwała wchodzi w życie z dniem 23 lutego 2022 r.

prof. dr hab. inż. Krzysztof Jóźwik
Rektor Politechniki Łódzkiej

*/-podpisany kwalifikowanym podpisem cyfrowym/*

# Program kształcenia
# w Interdyscyplinarnej Szkole Doktorskiej Politechniki Łódzkiej

§ 1
**Postanowienia ogólne**

1. Kształcenie w Interdyscyplinarnej Szkole Doktorskiej Politechniki Łódzkiej (ISD PŁ) jest prowadzone na podstawie programu kształcenia oraz indywidualnego planu badawczego (IPB).
2. Kształcenie w ISD PŁ przygotowuje do uzyskania stopnia doktora i kończy się złożeniem rozprawy doktorskiej w terminie określonym w indywidualnym planie badawczym.
3. Ukończenie kształcenia w ISD PŁ umożliwia doktorantowi osiągnięcie efektów uczenia się dla kwalifikacji na poziomie 8 Polskiej Ramy Kwalifikacji dla dyscypliny lub dziedziny, w ramach której powstaje rozprawa doktorska, określonych w Rozporządzeniu Ministra Nauki i Szkolnictwa Wyższego z dnia 14 listopada 2018 r. w sprawie charakterystyk drugiego stopnia efektów uczenia się dla kwalifikacji na poziomach 6-8 Polskiej Ramy Kwalifikacji (Dz. U. z 2018 r. poz. 2218).
4. Kształcenie w ISD PŁ stwarza warunki do:
   1) prowadzenia samodzielnych badań naukowych oraz współpracy naukowej w zespołach badawczych;
   2) przygotowania przez doktoranta publikacji naukowych i wniosków o finansowanie projektów naukowych, badawczych oraz wdrożeniowych;
   3) przygotowania rozprawy doktorskiej pod opieką promotora, promotorów lub promotora i promotora pomocniczego;
   4) uczestniczenia w życiu środowiska naukowego w kraju i za granicą;
   5) uzyskania efektów uczenia się dla kwalifikacji na poziomie 8 Polskiej Ramy Kwalifikacji oraz nabycia innych umiejętności oraz doświadczenia związanego z realizacją programu kształcenia i indywidualnego planu badawczego.
5. Program kształcenia w ISD PŁ jest prowadzony w 12 dyscyplinach zgodnie z poniższą listą:

**I. W dziedzinie nauk inżynieryjno-technicznych:**

1. Inżynieria materiałowa
2. Inżynieria mechaniczna
3. Automatyka, elektronika, elektrotechnika i technologie kosmiczne
4. Informatyka techniczna i telekomunikacja
5. Inżynieria lądowa, geodezja 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

6. Ścieżka kształcenia w każdej dyscyplinie obejmuje następujące przedmioty:
   1) Przedsiębiorczość i elementy prawa (PEP);
   2) Metodyka badań naukowych (MBN);
   3) Przedmioty podstawowe z dyscypliny (PP1, PP2, PP3);
   4) Przedmiot do wyboru z innej dyscypliny (PD);
   5) Przedmioty do wyboru realizowane w formie projektu (P1, P2, P3);
   6) Moduł „Hot topics in science and technology”;
   7) Seminarium badawcze.
7. Treści programowe poszczególnych przedmiotów określa właściwa Rada Dyscypliny, mając na względzie uzyskanie efektów uczenia się ustalonych w niniejszym programie kształcenia. Treści programowe zamieszczane są na stronie internetowej Interdyscyplinarnej Szkoły Doktorskiej Politechniki Łódzkiej.
8. Plan realizacji przedmiotów jest następujący:
   1) I rok:
      a) semestr 1 (grudzień, styczeń): PEP i MBN;
      b) semestr 2: PP1, PP2, PP3;
   3) II rok: P1, P2, P3, PD;
   4) semestr 2-6: seminarium badawcze, moduł „Hot topics in science and technology”.
9. PD jest realizowany poza dyscypliną doktoryzowania, a P3 poza obszarem doktoryzowania.
10. Doktorant w ramach realizacji programu kształcenia uczestniczy w seminarium badawczym oraz w module „Hot topics in Science and Technology”. Zasady realizacji seminarium oraz modułu „Hot topics in Science and Technology” określa Regulamin ISD PŁ. Moduł „Hot topics in Science and Technology” jest nieobowiązkowy dla uczestników programu Ministerialnego „Doktorat wdrożeniowy”.
11. Doktorant ma możliwość jednokrotnego powtarzania kursów PEP, MBN, PP1, PP2, PP3 w czasie II roku kształcenia. Przedmiot z innej dyscypliny oraz przedmioty do wyboru wskazywane są przez doktoranta w deklaracji składanej do biura ISD PŁ do końca kwietnia w pierwszym roku kształcenia doktoranta.
12. Warunkiem koniecznym przystąpienia doktoranta do oceny śródokresowej prócz akceptacji odpowiedniej rady dyscypliny jest zrealizowanie podstawy programowej w danej dyscyplinie.
13. Program kształcenia może przewidywać odbywanie praktyk zawodowych w formie prowadzenia zajęć lub uczestniczenia w ich prowadzeniu, w wymiarze nieprzekraczającym 60 godzin dydaktycznych rocznie. Zasady realizacji praktyk zawodowych określa Regulamin ISD PŁ. Praktyki poprzedzone są kursem przygotowawczym.
14. W wyniku realizacji kształcenia w Interdyscyplinarnej Szkole Doktorskiej Politechniki Łódzkiej, doktorant osiąga następujące efekty uczenia się:

| **Programowe efekty uczenia się** | | |
|---|---|---|
| **Oznaczenie** | **Po zakończeniu przedmiotu doktorant** | |
| **W zakresie wiedzy (zna i rozumie w jaki sposób):** | | |
| W1 | zidentyfikować, w oparciu o śledzenie w literaturze światowej opublikowanych wyników naukowych, monografii przeglądowych oraz osiągnięć technicznych lub w obszarze sztuki, zakres aktualnego stanu wiedzy oraz głównych nurtów badań z dziedziny związanej z przygotowywaną rozprawą doktorską | P8S_WG |
| W2 | poprawnie interpretować podstawowe zasady prawne, ekonomiczne i finansowe związane z działalnością naukową, badawczą, wdrożeniową, publikacyjna oraz ich implikacje dla praktyki, w tym upowszechnianie wiedzy w otwartym dostępie i związane z tym zagadnienia prawne i etyczne | P8S_WK |
| W3 | potrafi przywoływać i poprawnie interpretować podstawowe zagadnienia z wybranej dyscypliny dodatkowej nie związanej z wykonywaną pracą doktorską. | P8S_WG |

| | | |
|---|---|---|
| W4 | zastosować metodykę prowadzenia, realizacji i oceny badań naukowych odpowiednią dla obszaru związanego z przygotowywaną rozprawą doktorską | P8S_WG |
| **W zakresie umiejętności (potrafi):** | | |
| U1 | planować badania, przewidywać ich rezultaty i poprawnie analizować uzyskane wyniki naukowe, dokonywać analizy i twórczej syntezy dorobku naukowego i twórczego w celu identyfikowania i rozwiązywania problemów badawczych oraz związanych z działalnością innowacyjną | P8S_UW |
| U2 | porozumiewać się przy użyciu różnych kanałów i technik komunikacyjnych ze specjalistami z obszaru swojej dziedziny doktoryzowania, w języku rodzimym i co najmniej jednym języku obcym, biorąc pod uwagę szczególnie umiejętności związane z pisaniem i redagowaniem tekstów naukowych, różnymi formami prezentacji i prowadzenia dyskusji, a także uczestniczeniem, inicjowaniem i prowadzeniem dyskursu naukowego | P8S_UW<br>P8S_UK<br>P8S_UU |
| U3 | samodzielnie zdobywać wiedzę i poszerzać własne kompetencje oraz podejmować skuteczne działania zmierzające do rozwoju intelektualnego i kierowania własnym rozwojem naukowym inspirować także rozwój innych osób, uczestniczyć w wymianie doświadczeń i idei w ramach grup i zespołów badawczych, w tym także w środowisku międzynarodowym | P8S_UW |
| U4 | dobierać metodykę prowadzenia badań naukowych właściwą dla badanego zagadnienia związanego z przygotowywaną rozprawą doktorską | P8S_UO |
| **W zakresie kompetencji społecznych (jest gotów do):** | | |
| K1 | krytycznej oceny i analizy dorobku naukowego, w tym własnego, w obszarze doktoryzowania, realizacji zadań społecznych związanych z etosem badacza, działania na rzecz rozwoju gospodarki opartej na wiedzy | P8S_KK<br>P8S_KO |
| K2 | przestrzegania praw i obowiązków badacza, respektowania niezależności i należytej rzetelności prowadzenia badań naukowych, przestrzegania obowiązujących norm prawnych i etycznych | P8S_KR |

11. Efekty uczenia się są nabywane w następujący sposób:

| | |
|---|---|
| Przedsiębiorczość i element prawa (semestr 1) | W2, U3, K2 |
| Metodyka badań naukowych (semestr 1) | W4, U1, U2, K1 |
| Przedmiot podstawowy 1 (semestr 2) | W1, W4, U3, K1, K2 |
| Przedmiot podstawowy 2 (semestr 2) | W1, W4, U3, K1, K2 |
| Przedmiot podstawowy 3 (semestr 2) | W1, W4, U3, K1, K2 |
| Przedmiot z innej dyscypliny (semestr 3-4) | W1, W3, U3, K2 |
| Projekt 1 (semestr 3-4) | W4, U4, K1 |
| Projekt 2 (semestr 3-4) | W4, U4, K1 |
| Projekt 3 (semestr 3-4) | W4, U4, K1 |
| Indywidualny plan badawczy (semestr 1-8) | W1, W4, U1, U2, U3, U4, K1, K2 |
| Seminarium badawcze (semestr 2-6) | W1, W4, U2, K1, K2 |
| Moduł „Hot topics in science and technology” (semestr 2-6) | W1, U4, K1 |

§ 2
## Indywidualny plan kształcenia

1. W uzasadnionych przypadkach, np. doktorantów realizujących program ministerialny „Doktorat wdrożeniowy" lub realizujących interdyscyplinarną pracę doktorską przy współudziale dwóch promotorów z różnych dyscyplin, możliwe jest prowadzenie indywidualnego planu kształcenia (IPK).
2. IPK umożliwia wybór zajęć wchodzących w zakres podstawy programowej, przedmiotów obieralnych oraz innych przedmiotów, w tym realizowanych w formie projektów indywidualnych lub grupowych, również o charakterze interdyscyplinarnym.
3. Doktorant w ścisłej współpracy z promotorem, promotorami lub promotorem i promotorem pomocniczym opracowuje IPK bazując na podsiadanym wykształceniu i kompetencjach, założeniach i celach doktoratu, wymogach kwalifikacji dla poziomu 8 PRK oraz wymogach zawartych w regulaminie ISD PŁ.
4. Realizacja IPK umożliwia doktorantowi osiągnięcie efektów uczenia się dla kwalifikacji na poziomie 8 Polskiej Ramy Kwalifikacji dla dyscypliny lub dziedziny, w ramach której powstaje rozprawa doktorska.
5. IPK jest zatwierdzany przez Prezydium Rady Naukowej ISD PŁ oraz przedstawiciela dyscypliny do Rady Naukowej ISD PŁ, w której doktorant odbywa ścieżkę kształcenia.

§ 3
## Opis ścieżek kształcenia

Lista załączników do Programu kształcenia w Interdyscyplinarnej Szkole Doktorskiej Politechniki Łódzkiej PŁ:

1) Załącznik nr 1 do Programu kształcenia w Interdyscyplinarnej Szkole Doktorskiej Politechniki Łódzkiej – ścieżka kształcenia w dyscyplinie Inżynieria materiałowa;
2) Załącznik nr 2 do Programu kształcenia w Interdyscyplinarnej Szkole Doktorskiej Politechniki Łódzkiej – ścieżka kształcenia w dyscyplinie Inżynieria mechaniczna;
3) Załącznik nr 3 do Programu kształcenia w Interdyscyplinarnej Szkole Doktorskiej Politechniki Łódzkiej – ścieżka kształcenia w dyscyplinie Automatyka, elektronika, elektrotechnika i technologie kosmiczne;
4) Załącznik nr 4 do Programu kształcenia w Interdyscyplinarnej Szkole Doktorskiej Politechniki Łódzkiej – ścieżka kształcenia w dyscyplinie Informatyka techniczna i telekomunikacja;
5) Załącznik nr 5 do Programu kształcenia w Interdyscyplinarnej Szkole Doktorskiej Politechniki Łódzkiej – ścieżka kształcenia w dyscyplinie Inżynieria lądowa, geodezja i transport;
6) Załącznik nr 6 do Programu kształcenia w Interdyscyplinarnej Szkole Doktorskiej Politechniki Łódzkiej – ścieżka kształcenia w dyscyplinie Architektura i urbanistyka;
7) Załącznik nr 7 do Programu kształcenia w Interdyscyplinarnej Szkole Doktorskiej Politechniki Łódzkiej – ścieżka kształcenia w dyscyplinie Inżynieria chemiczna;
8) Załącznik nr 8 do Programu kształcenia w Interdyscyplinarnej Szkole Doktorskiej Politechniki Łódzkiej – ścieżka kształcenia w dyscyplinie Nauki chemiczne;
9) Załącznik nr 9 do Programu kształcenia w Interdyscyplinarnej Szkole Doktorskiej Politechniki Łódzkiej – ścieżka kształcenia w dyscyplinie Matematyka;
10) Załącznik nr 10 do Programu kształcenia w Interdyscyplinarnej Szkole Doktorskiej Politechniki Łódzkiej – ścieżka kształcenia w dyscyplinie Nauki fizyczne;
11) Załącznik nr 11 do Programu kształcenia w Interdyscyplinarnej Szkole Doktorskiej Politechniki Łódzkiej – ścieżka kształcenia w dyscyplinie Technologia żywności i żywienia;
12) Załącznik nr 12 do Programu kształcenia w Interdyscyplinarnej Szkole Doktorskiej Politechniki Łódzkiej – ścieżka kształcenia w dyscyplinie Nauki o zarządzaniu i jakości.

**TRAINING PROGRAM IN DISCIPLINE:**
**Materials Engineering**

1. Basic information

*Domain: Engineering and Technology*
*Discipline: Materials Engineering*
*Degree awarded: PhD in Materials Engineering*

2. Training demand

PhD studies in the field of Materials Engineering prepare their graduates for an employment in scientific laboratories, research and development establishments, universities – and technical universities in particular – as well as on management positions in the industry. The aim of the studies comprises an introduction of a 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.

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.

After finishing the studies 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.

3. Detailed entry requirements

Persons applying for an admission to the Interdisciplinary PhD Graduate School at the Lodz University of Technology 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.

4. Teaching methods

The methods of education include: lectures, exercises, laboratories, projects, research seminars, distance learning

5. Graduate's profile

A Materials Engineering Doctoral School graduate student 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. He 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. He 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. He 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 teaching 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.

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

6. Training plan (detailed description)

Format (Lecture – L, Tutorial – T, Project – P, Seminar – S)
D – organized by the discipline
ISD – organized by the doctoral school
AD – elective course from the university offer from different discipline

| Unit | Semester | Format | No. Of hrs. | ECTS |
|---|---|---|---|---|
| ISD | Enterprenuership and elements of Law (Sem 1/ second half) | L/T | 25 | 2 |
| D | Methodology of scientific research (Sem. 1/ Second half) | T | 15 | 2 |
| D | World trends in materials engineering (Sem. 2) | L | 15 | 2 |
| D | Construction materials (Sem. 2) | L | 15 | 2 |
| D | Research Methods of Materials Science (Sem. 2) | L | 15 | 2 |
| AD | Elective course from different discipline (second year) | L | 15 | 1 |
| D | Elective project 1 (second year) | P | 15 | 1 |
| D | Elective project 2 (second year) | P | 15 | 1 |
| D | Elective project 3 (second year) | P | 15 | 1 |
| D | Seminars/„Hot topics in science and technology" (Sem. 2-Sem. 6) | S | N/A | N/A |
| D | Seminar (Sem. 2-Sem. 6) | S | N/A | N/A |
| **Total** | | | **145** | **14** |

**TRAINING PROGRAM IN DISCIPLINE:**
**Mechanical Engineering**

1. Basic information

*Domain: Engineering and Technology*
*Discipline: Mechanical Engineering*
*Degree awarded: PhD in Mechanical Engineering*

2. Training demand

The PhD school 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. Students of the PhD school 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, PhD students are able to carry out research activities and projects and to implement novel solutions into industrial practice.

3. 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. 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.

4. Teaching methods

Teaching methods vary from course to course and during the course reflecting the teaching attitude towards mechanical engineering and demands of material being presented. These comprise lectures, presentations with details being presented on the board, seminars, projects and case study problem solving tutorials. Most likely, mixed methods are employed in course. Level of the courses is based on the profile of candidates and so are the methods which would be chosen through the course.

5. Graduate’s profile

A PhD school graduate in Mechanical Engineering demonstrates extensive knowledge in fundamental and applied sciences related to mechanical engineering and acquired skills allowing for solving interdisciplinary problems. He/she 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 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 mechanics and machine development and maintenance, designing, industrial technologies, IT, 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.

6. Training plan (detailed description)

Format (Lecture – L, Tutorial – T, Project – P, Seminar – S)
D – organized by the discipline
ISD – organized by the doctoral school
AD – elective course from the university offer from different discipline

| Unit | Semester | Format | No. Of hrs. | ECTS |
|---|---|---|---|---|
| ISD | Enterprenuership and elements of Law (Sem. 1/ second half) | L/T | 25 | 2 |
| D | Methodology of scientific research (Sem. 1/ Second half) | T | 15 | 2 |
| D | Mathematical modelling I (Sem. 2) | L | 15 | 2 |
| D | Mathematical modelling II (Sem. 2) | L, S | 15 | 2 |
| D | Mathematical modelling - project (Sem. 2) | P | 15 | 2 |
| AD | Elective course from different discipline (second year) | L | 15 | 1 |
| D | Elective project 1 (second year) | P | 15 | 1 |
| D | Elective project 2 (second year) | P | 15 | 1 |
| D | Elective project 3 (second year) | P | 15 | 1 |
| D | Seminars/„Hot topics in science and technology” (Sem. 2-Sem. 6) | S | N/A | N/A |
| D | Seminar (Sem. 2-Sem. 6) | S | N/A | N/A |
| **Total** | | | **145** | **14** |

**TRAINING PROGRAM IN DISCIPLINE:**
**Automation, Electronics, Electrical Engineering and Space Technologies**

1. Basic information

*Domain: Engineering and Technology*
*Discipline: Automation, Electronics, Electrical Engineering and Space Technologies*
*Degree awarded: PhD in Automation, Electronic and Electrical Engineering*

2. Training demand

The development of knowledge-based economy and industry 4.0 requires new technologies such as automation, electronic and electrical engineering increases the demand for high-class specialists, including Ph.D. in engineering and technical sciences, employed in higher education institutions, research and development units, management consulting companies, as well as in small and medium-sized enterprises. Graduates are expected to have a 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. Skills in team leadership, prioritizing and managing competing deadlines for themselves and others are also important.

3. 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.

4. Teaching methods

Teaching methods vary from course to course and throughout the course, reflecting the requirements of the material presented. They include traditional lectures, exercises, laboratories, projects, research seminars, e-learning, and mixed methods. Courses are offered to enhance knowledge in the areas of electrical, electronic, computer and control engineering. The level of the courses depends on the profile of the candidates, as do the methods that will be chosen for the course.

5. 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 automation, electronic and electrical 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).

6. Training plan (detailed description)

Format (Lecture – L, Tutorial – T, Project – P, Seminar – S, Laboratory – LB)
D – organized by the discipline
ISD – organized by the doctoral school
AD – elective course from the university offer from different discipline

| Unit | Semester | Format | No. of hrs. | ECTS |
|---|---|---|---|---|
| ISD | Enterprenuership and elements of Law (Sem. 1/ second half) | L/T | 25 | 2 |
| D | Methodology of scientific research (Sem. 1/ second half) | L/T | 15 | 2 |
| D | Signals and Systems (Sem. 2) | L/S | 15 | 2 |
| D | Modeling of Dynamical Systems (Sem. 2) | L/LB | 15 | 2 |
| D | Statistics for Control, Electronic, and Electrical Engineering (Sem. 2) | L/P | 15 | 2 |
| AD | Elective course from different discipline (second year) | L | 15 | 1 |
| D | Elective course 1 (second year) | P | 15 | 1 |
| D | Elective course 2 (second year) | P | 15 | 1 |
| D | Elective course 3 (second year) | P | 15 | 1 |
| D | Seminars/„Hot topics in science and technology” (Sem. 2-Sem. 6) | S | N/A | N/A |
| D | Seminar (Sem. 2-Sem. 6) | S | N/A | N/A |
| **Total** | | | **145** | **14** |

**TRAINING PROGRAM IN DISCIPLINE:**
**Information and Communication Technology**

1. Basic information

*Domain: Engineering and technology*
*Discipline: Information and Communication Technology*
*Degree awarded: PhD in Information and Communication Technology*

2. Training demand

Development of a knowledge-based economy in new technologies in the discipline of Information and Communication Technology 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.

3. 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, biomedical engineering, information technology or applied mathematics. Candidate should show the ability to self-education, organization of his or her own work, presentation, discussion and communication skills.

4. Teaching methods

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

5. Graduate's profile

Doctorate holder in Information and Communication Technology 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, problem solving, also in an 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.

6. Training plan (detailed description)

Format (Lecture – L, Tutorial – T, Project – P, Seminar – S)
D – organized by the discipline
ISD – organized by the doctoral school
AD – elective course from the university offer from different discipline

| Unit | Semester | Format | No. Of hrs. | ECTS |
|---|---|---|---|---|
| ISD | Enterprenuership and elements of Law (Sem. 1/ second half) | L/T | 25 | 2 |
| D | Methodology of scientific research (Sem. 1/ Second half) | S | 15 | 2 |
| D | Advanced data processing algorithms and structures (Sem. 2) | P | 15 | 2 |
| D | Advanced human-computer interaction methods (Sem. 2) | P | 15 | 2 |
| D | Computational intelligence (Sem. 2) | P | 15 | 2 |
| AD | Elective course from different discipline (second year) | L | 15 | 1 |
| D | Elective project 1 (second year) | P | 15 | 1 |
| D | Elective project 2 (second year) | P | 15 | 1 |
| D | Elective project 3 (second year) | P | 15 | 1 |
| D | Seminars/„Hot topics in science and technology” (Sem. 2-Sem. 6) | S | N/A | N/A |
| D | Seminar (Sem. 2-Sem. 6) | S | N/A | N/A |
| **Total** | | | **145** | **14** |

# TRAINING PROGRAM IN DISCIPLINE: Civil Engineering, Geodesy and Transport

1. Basic information

*Domain: Engineering and Technology*
*Discipline: Civil Engineering, Geodesy and Transport*
*Degree awarded: PhD in Civil Engineering and Transport*

2. 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, as well as in science and educational institutions such as high schools ranking among the top ones, higher education and research and development centres. According to thorough investigations civil and transport 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 and transport courses, lead to the habit of checking all details and foreseeing possible opportunities which is believed to be indispensable in a modern economy based on innovation. With such a profile of research and developed competencies, PhD graduates in civil engineering and transport 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 an increasing generation gap that has been observed. Moreover, graduates with attitude towards interdisciplinary research will bring some new ideas and possibly influence future research directions.

3. Detailed entry requirements

For PhD in civil engineering and transport there are eligible the 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 highly recommended since not all existing branches of civil engineering are present at LUT.

4. Teaching methods

Teaching methods vary from course to course reflecting the teaching attitude towards civil engineering and transport. These comprise, laboratory classes applying the up-to-date measuring techniques, presentations with details being shown on the board, seminars, projects, and case study problems being solved 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 students to broaden the knowledge and develop 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.

5. 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 its 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 and transport in particular 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.

6. Training plan

Format (Lecture – L, Tutorial – T, Project – P, Seminar – S)
D – organized by the discipline
ISD – organized by the doctoral school
AD – elective course from the university offer from different discipline

| Unit | Semester | Format | No. Of hrs. | ECTS |
|---|---|---|---|---|
| ISD | Enterprenuership and elements of Law (Sem. 1/ second half) | L/T | 25 | 2 |
| D | Methodology of scientific research (Sem. 1/ Second half) | T | 15 | 2 |
| D | Physics of Building Materials (Sem. 2) | L | 15 | 2 |
| D | Reliability and Optimization in Civil Engineering (Sem. 2) | L | 15 | 2 |
| D | Computational methods in non-linear solid mechanics (Sem. 2) | L | 15 | 2 |
| AD | Elective course from different discipline (second year) | L | 15 | 1 |
| D | Elective project 1 (second year) | P | 15 | 1 |
| D | Elective project 2 (second year) | P | 15 | 1 |
| D | Elective project 3 (second year) | P | 15 | 1 |
| D | Seminars/„Hot topics in science and technology" (Sem. 2-Sem. 6) | S | N/A | N/A |
| D | Seminar (Sem. 2-Sem. 6) | S | N/A | N/A |
| **Total** | | | **145** | **14** |

# 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*

2. 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 of the Doctoral School of TUL after obtaining a doctorate not only has extensive knowledge in the field of urban planning and architecture, but also has the ability to set, analyze and propose solutions to problems and their synthetic description. These features allow him to flexibly adapt to work also in areas that go beyond the disciplines of architecture and urban planning.

3. Detailed entry requirements

The formal requirement for candidates for studies is 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.

4. Teaching methods

Teaching methods vary from course to course and during the course reflecting the teaching attitude towards architecture and urban planning and demands of material being presented. These comprise traditional board and chalk lectures, presentations with details being presented on the board, seminars, projects and case study problem solving tutorials. Very often a sort of mixed method is employed. Level of the courses is based on the profile of candidates and so are the methods which would be chosen through the course.

5. Graduate’s profile

The graduate of the Doctoral School of TUL is a fully-fledged research worker, 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 studies, he acquires knowledge related to the most advanced technologies, trends and development trends under the supervision of lecturers from domestic and foreign centers, who can use them 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 up. In addition, they gain knowledge needed to work in organizations related to local and government administration, cultural institutions and activities in the area of creative industries.

They 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.

Graduates of the TUL Doctoral School can find employment in all industries related to architecture, urban planning, design and broadly defined culture. You can say with full confidence that people with a PhD degree 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 group has the opportunity to create innovative technologies and solutions in leading research and development centers in the field of architecture and urban planning.

6. Training plan (detailed description)

Format (Lecture – L, Tutorial – T, Project – P, Seminar – S)
D – organized by the discipline
ISD – organized by the doctoral school
AD – elective course from the university offer from different discipline

| Unit | Semester | Format | No. Of hrs. | ECTS |
|---|---|---|---|---|
| ISD | Enterprenuership and elements of Law (Sem. 1/ second half) | L/T | 25 | 2 |
| D | Methodology of scientific research (Sem. 1/ Second half) | T | 15 | 2 |
| D | Aesthetics and Aesthetics of Architecture (Sem. 2) | L | 15 | 2 |
| D | Heritage conservation and urban regeneration within the architecture and urban planning research domain (Sem. 2) | L | 15 | 2 |
| D | Research Methods in Urban Studies (Sem. 2) | L | 15 | 2 |
| AD | Elective course from different discipline (second year) | L | 15 | 1 |
| D | Elective project 1 (second year) | P | 15 | 1 |
| D | Elective project 2 (second year) | P | 15 | 1 |
| D | Elective project 3 (second year) | P | 15 | 1 |
| D | Seminars/„Hot topics in science and technology” (Sem. 2-Sem. 6) | S | N/A | N/A |
| D | Seminar (Sem. 2-Sem. 6) | S | N/A | N/A |
| **Total** | | | **145** | **14** |

**TRAINING PROGRAM IN DISCIPLINE:**
**Chemical Engineering**

1. Basic information

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

2. 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.

3. 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.

4. Teaching methods

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

5. Graduate's profile

The graduates of the IDS TUL 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.

6. Training plan

Format (Lecture – L, Tutorial – T, Project – P, Seminar – S)
D – organized by the discipline
ISD – organized by the doctoral school
AD – elective course from the university offer from different discipline

| Unit | Semester | Format | No. Of hrs. | ECTS |
|---|---|---|---|---|
| ISD | Enterprenuership and elements of Law (Sem. 1/ second half) | L/T | 25 | 2 |
| D | Methodology of scientific research (Sem. 1/ Second half) | T | 15 | 2 |
| D | Transport phenomena 1 (Sem. 2) | L | 15 | 2 |
| D | Transport phenomena 2 (Sem. 2) | L | 15 | 2 |
| D | Introduction to Chemical Reactor and Bioreactor Engineering (Sem. 2) | L | 15 | 2 |
| AD | Elective course from different discipline (second year) | L | 15 | 1 |
| D | Elective project 1 (second year) | P | 15 | 1 |
| D | Elective project 2 (second year) | P | 15 | 1 |
| D | Elective project 3 (second year) | P | 15 | 1 |
| D | Seminars/„Hot topics in science and technology” (Sem. 2-Sem. 6) | S | N/A | N/A |
| D | Seminar (Sem. 2-Sem. 6) | S | N/A | N/A |
| **Total** | | | **145** | **14** |

**TRAINING PROGRAM IN DISCIPLINE:**
**Chemical Sciences**

1. Basic information

*Domain: Natural Sciences*
*Discipline: Chemical Sciences*
*Degree awarded: PhD in Chemical Sciences*

2. 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.

3. Detailed entry requirements

Graduates from master courses 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.

4. Teaching methods

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

5. Graduate’s profile

The training prepares 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 these 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.

6. Training plan

Training plan (detailed description)

Format (Lecture – L, Tutorial – T, Project – P, Seminar – S)
D – organized by the discipline
ISD – organized by the doctoral school
AD – elective course from the university offer from different discipline

| Unit | Course | Format | No. of hr. | ECTS |
|---|---|---|---|---|
| ISD | Entrepreneurship and Elements of Law (Sem. 1/second half) | L/T | 25 | 2 |
| D | Methodology of scientific research (Sem. 1/second half) | P | 15 | 2 |
| D | Advanced Inorganic and Organic Chemistry (Sem. 2) | L | 15 | 2 |
| D | Advanced Molecular and Macromolecular Materials Science (Sem. 2) | L | 15 | 2 |
| D | Advanced Physical Chemistry (Sem. 2) | L | 15 | 2 |
| AD | Elective course from different discipline (second year) | L | 15 | 1 |
| D | Elective project 1 (second year) | P | 15 | 1 |
| D | Elective project 2 (second year) | P | 15 | 1 |
| D | Elective project 3 (second year) | P | 15 | 1 |
| D | Seminar „Hot topics in science and technology” (Sem. 2-Sem. 6) | S | N/A | N/A |
| D | Seminar (Sem. 2-Sem. 6) | S | N/A | N/A |
| **Total** | | | **145** | **14** |

**TRAINING PROGRAM IN DISCIPLINE:**
**Mathematics**

1. Basic information

*Domain: Natural Sciences*
*Discipline: Mathematics*
*Degree awarded: PhD in Mathematics*

2. Training demand

The knowledge-based society requires highly skilled experts in various branches of industry, banking system, high schools ranking among the top ones, higher education and research and development units. According to the through investigations mathematicians are commonly those with lowest unemployment rate for the PhDs. This is a consequence of training which is being implemented and which is based on utmost scrutiny and a 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 especially 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 an attitude to interdisciplinary research will bring some new ideas and may influence future research directions.

3. 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 main 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 and suitably commented;
B) scientific achievements obtained so far- if any;
C) classical oral exam covering the following topics (questions are formulated by the commission during discussion):
    1. Mathematical analysis (continuity, differentiability and integrability of functions of one and several variables - basic notions, theorems and relations).
    3. Fundamental notions and theorems in functional analysis (examples of Banach and Hilbert spaces, theorems of Hahn-Banach, Banach-Steinhaus and Banach-Alaoglu, open mapping and closed graph theorems) with necessary background information.
    4. Fundamentals in topology (continuity, compactness, connectedness, homeomorphisms).
    5. Lebesgue measure and integration (construction, integrability, modes of convergence, comparison with the Riemann Integral integral).
    6. Numerical analysis and differential equations (algorithm, convergence, approximation vs interpolation, solvability, uniqueness, continuation).
    7. Basics of probability theory (random variables and their characteristics, laws of large numbers, central limit theorem).

8. Linear algebra (Jordan matrices, eigenvalues, linear mappings).
9. Discrete mathematics (induction, recurrence, relational structures, basics of combinatorics and graph theory).

4. Teaching methods

Teaching methods vary from course to course and during the course reflecting the teaching attitude towards mathematics and demands of material being presented. These comprise traditional board and chalk lectures, presentations with details being presented on the board, seminars, projects and case study problem solving tutorials. Very often a sort of mixed method 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.

5. 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, problem solving, also in an 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.

6. Training plan (detailed description)

Format (Lecture – L, Tutorial – T, Project – P, Seminar – S)
D – organized by the discipline
ISD – organized by the doctoral school
AD – elective course from the university offer from different discipline

| Unit | Semester | Format | No. Of hrs. | ECTS |
|---|---|---|---|---|
| ISD | Entrepreneurship and elements of Law (Sem. 1/ second half) | L/T | 25 | 2 |
| D | Methodology of scientific research (Sem. 1/ Second half) | T | 15 | 2 |
| D | Modern mathematical analysis (Sem. 2) | L | 15 | 2 |
| D | Stochastic processes (Sem. 2) | L | 15 | 2 |
| D | Selected problems in graph theory (Sem. 2) | P | 15 | 2 |
| AD | Elective course from different discipline (second year) | L | 15 | 1 |
| D | Elective project 1 (second year) | P | 15 | 1 |
| D | Elective project 2 (second year) | P | 15 | 1 |
| D | Elective project 3 (second year) | P | 15 | 1 |
| D | Seminars/„Hot topics in science and technology" (Sem. 2-Sem. 6) | S | N/A | N/A |
| D | Seminar (Sem. 2-Sem. 6) | S | N/A | N/A |
| **Total** | | | **145** | **14** |

**TRAINING PROGRAM IN DISCIPLINE:**
**Physical Sciences**

1. Basic information

*Domain: Natural Sciences*
*Discipline: Physical Sciences*
*Degree awarded: PhD in Physical Sciences*

2. 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.

3. 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. PhD candidates need to show good performance at undergraduate level. Admission to the PhD program in physics is on competitive base. The candidates are advised to get in touch with possible supervisors and discuss the topic of the future PhD project, prior to the PhD interview. During the interview candidates are required to be able to briefly present their MSc thesis and other scientific achievements, future goals, and to prove knowledge of physics at undergraduate level.

4. Teaching methods

Teaching methods are course dependent and include: lectures, tutorials, laboratory, seminars, participation in workshops, conferences. Collaborative work in research groups.

5. 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 gradate is capable of establishing collaborations and conducting team research projects 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.

6. Training plan (detailed description)

Format (Lecture – L, Tutorial – T, Project – P, Seminar – S)
D – organized by the discipline
ISD – organized by the doctoral school
AD – elective course from the university offer from different discipline

| Unit | Semester | Format | No. Of hrs. | ECTS |
|---|---|---|---|---|
| ISD | Entrepreneurship and elements of law (Sem. 1/ second half) | L/T | 25 | 2 |
| D | Methodology of scientific research (Sem. 1) | T | 15 | 2 |
| D | Current trends in physical sciences 1 (Sem. 1) | L | 15 | 2 |
| D | Advanced research planning and management in physical sciences (Sem. 2) | L | 15 | 2 |
| D | Current trends in physical sciences 2 (Sem. 2) | L | 15 | 2 |
| AD | Elective course from different discipline (second year) | L | 15 | 1 |
| D | Elective project 1 (second year) | P | 15 | 1 |
| D | Elective project 2 (second year) | P | 15 | 1 |
| D | Elective project 3 (second year) | P | 15 | 1 |
| D | Seminars/„Hot topics in science and technology” (Sem. 2-Sem. 6) | S | N/A | N/A |
| D | Seminar (Sem. 2-Sem. 6) | S | N/A | N/A |
| **Total** | | | **145** | **14** |

**TRAINING PROGRAM IN DISCIPLINE:**
**Food and Nutrition Technology**

1. Basic information

*Domain: Agricultural Sciences*
*Discipline: Food and Nutrition Technology*
*Degree awarded: PhD in Food and Nutrition Technology*

2. Training demand

The mission of the International Doctoral School in Food and Nutrition Technology at Lodz University of Technology is 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. The IDS graduates after obtaining the degree of doctor of 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.

3. Detailed entry requirements

A formal requirement for candidates for studies at IDS is the completion of master's studies in food and nutrition technology or chemical engineering or other related fields. In addition, the 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.

4. Teaching methods

Lectures, tutorials, laboratories, projects, scientific seminars.

5. Graduate’s profile

The graduates know and understand world scientific 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 new elements to these achievements. The 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, agri-food, cosmetics and pharmaceutical industries. They can also modify, evaluate and consult

new technological and product solutions in terms of their efficiency, profitability and innovation – also in the wider context of a sustainable and low-carbon circular economy.

6. Training plan (detailed description)

Format (Lecture – L, Tutorial – T, Project – P, Seminar – S, Laboratory – LB)
D – organized by the discipline
ISD – organized by the doctoral school
AD – elective course from the university offer from different discipline

| Unit | Semester | Format | No. of hr. | ECTS |
|---|---|---|---|---|
| ISD | Entrepreneurship and Elements of Law (Sem. 1/second half) | L/T | 25 | 2 |
| D | Methodology of scientific research (Sem. 1/second half) | T | 15 | 2 |
| D | Modern Trends in Food Technology (Sem. 2) | L/LB | 15 | 2 |
| D | Advances in Fermented Food and Beverages (Sem. 2) | L/LB | 15 | 2 |
| D | Modern Microbiological Analysis in Food Industry (Sem. 2) | L | 15 | 2 |
| AD | Elective course from additional discipline | L | 15 | 1 |
| D | Elective project 1 (second year) | P | 15 | 1 |
| D | Elective project 2 (second year) | P | 15 | 1 |
| D | Elective project 3 (second year) | P | 15 | 1 |
| D | Seminar „Hot topics in science and technology” (Sem. 2-Sem. 6) | S | N/A | N/A |
| D | Seminar (Sem. 2-Sem. 6) | S | N/A | N/A |
| **Total** | | | **145** | **14** |

**TRAINING PROGRAM IN DISCIPLINE:**
**Management and Quality Studies**

1. Basic information

*Domain: Social sciences*
*Discipline: Management and quality studies*
*Degree awarded: PhD in Management and quality studies*

2. 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 studies, 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.

3. 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.

4. Teaching methods

Lectures, tutorials, laboratories, projects, scientific seminars.

5. Graduate’s profile

The graduate of IDS TUL in the discipline of management and quality studies 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.

6. Training plan (detailed description)

Format (Lecture – L, Tutorial – T, Project – P, Seminar – S)
D – organized by the discipline
ISD – organized by the doctoral school
AD – elective course from the university offer from different discipline

| Unit | Semester | Format | No. of hr. | ECTS |
|---|---|---|---|---|
| ISD | Entrepreneurship and elements of Law (Sem. 1/ second half) | L/T | 25 | 2 |
| D | Methodology of scientific research (Sem. 1/ Second half) | T | 15 | 2 |
| D | Management concepts (Sem. 2) | L | 15 | 2 |
| D | Quantitative methods in social sciences (Sem. 2) | L | 15 | 2 |
| D | Qualitative methods in social sciences (Sem. 2) | L | 15 | 2 |
| AD | Elective course from additional discipline | L | 15 | 1 |
| D | Elective project 1 (second year) | P | 15 | 1 |
| D | Elective project 2 (second year) | P | 15 | 1 |
| D | Elective project 3 (second year) | P | 15 | 1 |
| D | Seminar „Hot topics in science and technology” (Sem. 2-Sem. 6) | S | N/A | N/A |
| D | Seminar (Sem. 2-Sem. 6) | S | N/A | N/A |
| **Total** | | | **145** | **14** |