Zał. nr 4 do ZW 64/2012

**FACULTY OF PURE AND APPLIED MATHEMATICS**
**SUBJECT CARD**

**Name in Polish: Równania różniczkowe cząstkowe z zastosowaniami w fizyce i przemyśle**
**Name in English: Partial differential equations with applications in physics and industry**
**Main field of study (if applicable): APPLIED MATHEMATICS**
**Specialization (if applicable): Mathematics for Industry and Commerce**
**Level and form of studies: ~~1st/~~ 2nd* level, full-time / ~~part-time~~***
**Kind of subject: obligatory ~~/ optional / university-wide~~***
**Subject code MAT001536**
**Group of courses YES / ~~NO~~***

| | Lecture | Classes | Laboratory | Project | Seminar |
|---|---|---|---|---|---|
| Number of hours of organized classes in University (ZZU) | 30 | 30 | | | |
| Number of hours of total student workload (CNPS) | 180 | | | | |
| Form of crediting | Examination / crediting with grade* | Examination / crediting with grade* | Examination / crediting with grade* | Examination / crediting with grade* | Examination / crediting with grade* |
| For group of courses mark (X) final course | X | | | | |
| Number of ECTS points | 6 | | | | |
| including number of ECTS points for practical (P) classes | | 4 | | | |
| including number of ECTS points for direct teacher-student contact (BK) classes | 1 | 2 | | | |

*delete as applicable

**PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES**

1. Student knows and can apply classical notions and methods of real and complex analysis.
2. Student knows and can apply elementary notions and methods of ordinary differential equations.

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**SUBJECT OBJECTIVES**

C1 Study of basic notions and acquisition of knowledge in the area of differential equations.
C2 Study of basic applications of partial differential equations in science, technology and industry.
C3 Acquisition of basic abilities in mathematical modelling by partial differential equations.

**SUBJECT EDUCATIONAL EFFECTS**

relating to knowledge the student:

PEK_W01 knows the most important theorems from main areas of differential equations

PEK_W02 knows basics of modelling by differential equations in technology and natural sciences, especially in physics, chemistry and biology

relating to skills the student:

PEK_U01 can analyze basic problems of differential equations,

PEK_U02 can construct mathematical models with the usage of differential equations in concrete applications of mathematics.

relating to social competences the student:

PEK_K01 can, without assistance, search for necessary information in the literature, also in foreign languages

PEK_K02 understands necessity of systematic and individual work on the material of the course.

**PROGRAMME CONTENT**

| **Form of classes - lecture** | | **Number of hours** |
|---|---|---|
| Lec1 | A reminder of information concerning first order partial differential equations. Methods of characteristics, weak solutions and shock waves. | 4 |
| Lec2 | Second order partial differential equations and their classification. Physical motivations. | 2 |
| Lec3 | Parabolic equations and their applications (heat, diffusion). Initial-boundary problems, method of separation of variables, Fourier transform, fundamental solution, maximum principle. | 8 |
| Lec4 | Hyperbolic equations and their applications (vibration of strings, membranes and beams; acoustical, mechanical and electromagnetic waves). D'Alembert's solution, initial-boundary problems, method of separation of variables, Kirchhoff's solution, Huygens' principle. | 8 |
| Lec5 | Elliptic equations and their applications (stationary temperature distribution, gravitational and electrostatic potential). Boundary value problems, eigenfunctions, Poisson's equation, Green's function. | 6 |
| Lec6 | The calculus of variations and its applications. Euler-Lagrange equation, Lagrangian mechanics, geodesic equation, minimal surface equation. | 2 |
| | Total hours | **30** |

| **Form of classes - Class** | | **Number of hours** |
|---|---|---|
| Cl1 | Solving of problems for differential equations and their applications. | **30** |
| | Total hours | **30** |

**TEACHING TOOLS USED**

N1. Lecture – traditional method

N2. Tutorial class

N3. Consultations

N4. Student’s personal work – preparation for the laboratory

**EVALUATION OF SUBJECT EDUCATIONAL EFFECTS ACHIEVEMENT**

| **Evaluation** (F – forming (during semester), P – concluding (at semester end) | Educational effect number | Way of evaluating educational effect achievement |
|---|---|---|
| F1 | PEK_W01<br>PEK_W02<br>PEK_K01 | exam |
| F2 | PEK_U01<br>PEK_U02<br>PEK_K01 | Oral presentations, tests, written reports. |
| P=0.5*F1+0.5*F2 | | |

**PRIMARY AND SECONDARY LITERATURE**

**PRIMARY LITERATURE:**


[1] S.J.Farlow, Partial Differential Equations for Scientists and Engineers, Dover Publications, 1993.

[2] R.Haberman, Applied Partial Differential Equations with Fourier Series and Boundary Value Problems, Pearson, 2012.

**[3]** A. N. Tichonow, A. A. Samarski, Równania fizyki matematycznej, PWN 1963.


**SECONDARY LITERATURE:**


[1] J. Ockendon, S. Howison, A. Lacey & A. Movchan, Applied Partial Differential Equations, Oxford University Press, Oxford 1999.

[2] L. C. Evans, Równania różniczkowe cząstkowe, PWN 2002.


**SUBJECT SUPERVISOR (NAME AND SURNAME, E-MAIL ADDRESS)**


**Prof. dr hab. Wojciech Okrasiński** (wojciech.okrasinski@pwr.edu.pl)

**dr inż. Łukasz Płociniczak (lukasz.plociniczak@pwr.edu.pl)**

MATRIX OF CORRELATION BETWEEN EDUCATIONAL EFFECTS FOR SUBJECT
**DIFFERENTIAL EQUATIONS MAT001536**
AND EDUCATIONAL EFFECTS FOR MAIN FIELD OF STUDY
**APPLIED MATHEMATICS**
AND SPECIALIZATION **MATHEMATICS FOR INDUSTRY AND COMMERCE**

| Subject educational effect | Correlation between subject educational effect and educational effects defined for main field of study and specialization (if applicable)** | Subject objectives*** | Programme content*** | Teaching tool number*** |
|---|---|---|---|---|
| **PEK_W01 (knowledge)** | K2MST_W03<br>K2MST_mic_W01<br>K2MST_mic_W02 | C1-C3 | Lec1-Lec15 | 1, 3 |
| **PEK_W02** | K2MST_W07<br>K2MST_mic_W03 | C1-C3 | Lec1-Lec15 | 1, 3 |
| **PEK_U01 (skills)** | K2MST_U06<br>K2MST_U08<br>K2MST_U09<br>K2MST_U15<br>K2MST_mic_U01 | C1-C3 | Cl1 | 2, 3, 4 |
| **PEK_U02** | K2MST_U16<br>K2MST_U24<br>K2MST_U25<br>K2MST_mic_U02<br>K2MST_mic_U03 | C1-C3 | Cl1 | 2, 3, 4 |
| **PEK_K01 (competences)** | K2MST_K06<br>K2MST_mic_K01 | C1-C3 | Lec1-Lec15<br>Cl1 | 1, 2, 3, 4 |
| **PEK_K02** | K2MST_K01<br>K2MST_mic_K02 | C1-C3 | Lec1-Lec15<br>Cl1 | 1, 2, 3, 4 |

** - enter symbols for main-field-of-study/specialization educational effects
*** - from table above

Zał. nr 4 do ZW 64/2012

**FACULTY OF PURE AND APPLIED MATHEMATICS**
**SUBJECT CARD**

**Name in Polish: Matematyka finansowa**
**Name in English: Economathematics**
**Main field of study (if applicable): Applied Mathematics**
**Specialization (if applicable): Financial and Actuarial Mathematics**
**Level and form of studies: ~~1st~~/ 2nd* level, full-time ~~/ part-time~~***
**Kind of subject: obligatory ~~/ optional / university-wide~~***
**Subject code MAT001562**
**Group of courses YES /~~NO~~***

| | Lecture | Classes | Laboratory | Project | Seminar |
|---|---|---|---|---|---|
| Number of hours of organized classes in University (ZZU) | 30 | 30 | | | |
| Number of hours of total student workload (CNPS) | 150 | | | | |
| Form of crediting | Examination / ~~crediting with grade~~* | Examination / crediting with grade* | Examination / crediting with grade* | Examination / crediting with grade* | Examination / crediting with grade* |
| For group of courses mark (X) final course | X | | | | |
| Number of ECTS points | 5 | | | | |
| including number of ECTS points for practical (P) classes | 2 | 2 | | | |
| including number of ECTS points for direct teacher-student contact (BK) classes | 1,5 | 1,5 | | | |

*delete as applicable

**PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES**

1. Student has an elementary knowledge of financial markets and discrete models of financial mathematics

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**SUBJECT OBJECTIVES**

C1 Learning and mastery of key concepts and methods in the field of financial mathematics

**SUBJECT EDUCATIONAL EFFECTS**

relating to knowledge:
PEK_W01 knows the most important theorems and hypotheses of financial mathematics
PEK_W02 knows the basics of stochastic modeling in financial mathematics
relating to skills:
PEK_U01 can construct mathematical models used in financial mathematics
relating to social competences:
PEK_K01 can by hisself search for information in the literature, even in foreign languages

**PROGRAMME CONTENT**

| Form of classes - lecture | | Number of hours |
|---|---|---|
| Lec 1 | Black-Scholes model | 4 |
| Lec 2 | Stochastic calculus and its application to the valuation of assets and liabilities and design hedging strategies | 4 |
| Lec 3 | Feynman-Kac formula and Blacka-Scholes formula | 2 |
| Lec 4 | Bachelier model | 2 |
| Lec 5 | Risk-Neutral and Real World scenarios, deflator and its applications | 2 |
| Lec 6 | Modeling of term structure | 2 |
| Lec 7 | Vasicek and Cox-Ingerson-Ross models, HJM model, LIBOR model | 4 |
| Lec 8 | Calibration of interest rate instruments | 2 |
| Lec 9 | Valuation of debt instruments and interest rate derivatives (bonds, cap/ floor, caplet/floorlet and swaptions) | 2 |
| Lec10 | Subdiffusive Black-Scholes and Bachelier models | 2 |
| Lec11 | Fractional Brownian motion in finance | 2 |
| Lec12 | Gerber-Shiu model, Esscher transform | 2 |
| | Total hours | 30 |

| Form of classes - class | | Number of hours |
|---|---|---|
| Cl 1 | Illustration of all models.. Analytical and computer methods. Examples of pricing derivatives. | 30 |
| | Total hours | 30 |

| TEACHING TOOLS USED |
|---|
| N1. Lecture problem - traditional method.<br>N2. Problem and counting exercises.<br>N3. Consultations.<br>N4. Student's self work - preparation for exercises. |

**EVALUATION OF SUBJECT EDUCATIONAL EFFECTS ACHIEVEMENT**

| **Evaluation** (F – forming (during semester), P – concluding (at semester end) | Educational effect number | Way of evaluating educational effect achievement |
|---|---|---|
| F1 | PEK_W01<br>PEK_W02 | exam |

| | | |
|---|---|---|
| | PEK_K01 | |
| F2 | PEK_U01<br>PEK_K01 | oral responses, tests, small tests |
| P=0.5*F1+0.5*F2 | | |

| **PRIMARY AND SECONDARY LITERATURE** |
|---|
| **PRIMARY LITERATURE:** |
| [1] A. Weron, R. Weron (1998) Inżynieria finansowa, WNT |
| **SECONDARY LITERATURE:** |
| [1] A. Jakubowski, A. Palczewski, M. Rutkowski, Ł. Stettner (2003) Matematyka finansowa, WNT.<br>[2] M. Musiela, M. Rutkowski (1997) Martingale methods in financial modelling, Springer. |
| **SUBJECT SUPERVISOR (NAME AND SURNAME, E-MAIL ADDRESS)** |
| **Dr hab. Marcin Magdziarz** (Marcin.Magdziarz@pwr.edu.pl) |

MATRIX OF CORRELATION BETWEEN EDUCATIONAL EFFECTS FOR SUBJECT **ECONOMATHEMATICS MAT001562** AND EDUCATIONAL EFFECTS FOR MAIN FIELD OF STUDY **APPLIED MATHEMATICS** AND SPECIALIZATION **FINANCIAL AND ACTUARIAL MATHEMATICS**

| **Subject educational effect** | **Correlation between subject educational effect and educational effects defined for main field of study and specialization (if applicable)**** | **Subject objectives***** | **Programme content***** | **Teaching tool number***** |
|---|---|---|---|---|
| **PEK_W01 (knowledge)** | K2MST_W03<br>K2MST_W09<br>K2MST_fam_W01 | C1 | Lec 1-Lec 10 | 1, 3 |
| **PEK_W02** | K2MST_W16<br>K2MST_W17<br>K2MST_W18<br>K2MST_fam_W02<br>K2MST_fam_W03 | C1 | Lec 1-Lec 10 | 1, 3 |
| **PEK_U01 (skills)** | K2MST_U15<br>K2MST_U20<br>K2MST_U24<br>K2MST_U25<br>K2MST_fam_U01<br>K2MST_fam_U02<br>K2MST_fam_U03 | C1 | Cl 1 | 2, 3, 4 |
| **PEK_K01 (competences)** | K2MST_K06<br>K2MST_fam_K01<br>K2MST_fam_K02 | C1 | Lec 1-Lec 10,<br>Cl 1 | 1, 2, 3, 4 |

** - enter symbols for main-field-of-study/specialization educational effects

*** - from table above

**FACULTY OF PURE AND APPLIED MATHEMATICS**
**SUBJECT CARD**

**Name in Polish: MODELE UBEZPIECZEŃ ŻYCIOWYCH**
**Name in English: Life insurance models**
**Main field of study (if applicable): Applied Mathematics**
**Specialization (if applicable): Financial and Actuarial Mathematics**
**Level and form of studies: ~~1st~~/ 2nd* level, full-time / ~~part-time~~***
**Kind of subject: obligatory ~~/ optional / university-wide*~~**
**Subject code MAT001564**
**Group of courses YES / ~~NO~~***

| | Lecture | Classes | Laboratory | Project | Seminar |
|---|---|---|---|---|---|
| Number of hours of organized classes in University (ZZU) | 30 | 30 | | | |
| Number of hours of total student workload (CNPS) | 150 | | | | |
| Form of crediting | Examination / ~~crediting with grade*~~ | Examination / crediting with grade* | Examination / crediting with grade* | Examination / crediting with grade* | Examination / crediting with grade* |
| For group of courses mark (X) final course | X | | | | |
| Number of ECTS points | 5 | | | | |
| including number of ECTS points for practical (P) classes | 2 | 2 | | | |
| including number of ECTS points for direct teacher-student contact (BK) classes | 1.5 | 1.5 | | | |

*delete as applicable

**PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES**

1. Student knows and can apply basic concepts of the probability theory

\

**SUBJECT OBJECTIVES**

C1 Study of the classical concepts and acquisition of the knowledge of life insurance mathematics

**SUBJECT EDUCATIONAL EFFECTS**

relating to knowledge:
PEK_W01 knows the most important concepts of life insurance mathematics
PEK_W02 knows principles of stochastic modeling in life insurance mathematics
relating to skills:
PEK_U01 can construct mathematical models used in life insurance mathematics
relating to social competences:
PEK_K01 can, without assistance, search for necessary information in the literature, also in foreign languages

**PROGRAMME CONTENT**

| **Form of classes - lecture** | | **Number of hours** |
|---|---|---|
| Lec 1 | Distribution of the future lifetime including probability of | 2 |

| | | |
|---|---|---|
| | survival and death, force of mortality. | |
| Lec 2 | Life tables | 2 |
| Lec 3 | Assumptions for fractional ages | 2 |
| Lec 4 | Analytical laws of mortality | 2 |
| Lec 5 | Multiple state models with estimation methods of their parameters and estimation methods of future lifetime (including Nelson-Aalen and Kaplan-Meier estimators) | 4 |
| Lec 6 | Life insurance payable at the moment death and at the end of the year of death | 3 |
| Lec 7 | Discrete and continuous annuities | 3 |
| Lec 8 | Net premiums in fully discrete and continuous insurance contracts | 4 |
| Lec 9 | Commutation functions | 2 |
| Lec 10 | Gross premiums | 2 |
| Lec 11 | Pension funds | 4 |
| | Total hours | **30** |

| **Form of classes - class** | | **Number of hours** |
|---|---|---|
| Cl 1 | Solving of problems illustrating theory given in the lectures, solving of problems from actuarial exams | 30 |
| | Total hours | **30** |

**TEACHING TOOLS USED**

N1. Lecture – traditional method.
N2. Problem-solving classes.
N3. Consultations.
N4. Student's self-work – preparation for the classes.

## EVALUATION OF SUBJECT EDUCATIONAL EFFECTS ACHIEVEMENT

| **Evaluation** (F – forming (during semester), P – concluding (at semester end) | Educational effect number | Way of evaluating educational effect achievement |
|---|---|---|
| F1 | PEK_W01<br>PEK_W02<br>PEK_K01 | exam |
| F2 | PEK_U01<br>PEK_K01 | oral presentations, tests |
| P=0.5*F1+0.5*F2 | | |

**PRIMARY AND SECONDARY LITERATURE**

**PRIMARY LITERATURE:**

[1] N. L. Bowers i inni „Actuarial Mathematics", The Society of Actuaries, Itasca, Illinois 1997
[2] H. U. Gerber „Life insurance mathematics", Springer-Verlag, Berlin 1997
[3] D. Dickson, M. Hardy, H. Waters „Actuarial mathematics for life contingent risks" 2nd ed.; Cambridge University Press, Cambridge 2013

**SUBJECT SUPERVISOR (NAME AND SURNAME, E-MAIL ADDRESS)**

**Dr hab. inż. Krzysztof Burnecki, prof. nadzw.** (Krzysztof.Burnecki@pwr.edu.pl)

**Dr hab. inż. Agnieszka Wyłomańska, prof. nadzw.** (Agnieszka.Wylomanska@pwr.edu.pl)

MATRIX OF CORRELATION BETWEEN EDUCATIONAL EFFECTS FOR SUBJECT **LIFE INSURANCE MODELS MAT001564** AND EDUCATIONAL EFFECTS FOR MAIN FIELD OF STUDY **APPLIED MATHEMATICS** AND SPECIALIZATION **FINANCIAL AND ACTUARIAL MATHEMATICS**

| Subject educational effect | Correlation between subject educational effect and educational effects defined for main field of study and specialization (if applicable)** | Subject objectives*** | Programme content*** | Teaching tool number*** |
|---|---|---|---|---|
| **PEK_W01 (knowledge)** | K2MST_W03<br>K2MST_fam_W01 | C1 | Lec 1- Lec 15 | 1,3 |
| **PEK_W02** | K2MST_W09<br>K2MST_W22<br>K2MST_fam_W02<br>K2MST_fam_W03 | C1 | Lec 1- Lec 15 | 1,3 |
| **PEK_U01 (skills)** | K2MST_U15<br>K2MST_U24<br>K2MST_U25<br>K2MST_fam_U01<br>K2MST_fam_U02<br>K2MST_fam_U03 | C1 | Cl 1 | 2,3,4 |
| **PEK_K01 (competences)** | K2MST_K06<br>K2MST_fam_K01<br>K2MST_fam_K02 | C1 | Lec 1- Lec 15,<br>Cl 1 | 1,2,3,4 |

** - enter symbols for main-field-of-study/specialization educational effects
*** - from table above

**FACULTY OF PURE AND APPLIED MATHEMATICS**
**SUBJECT CARD**

**Name in Polish: Zarządzanie Ryzykiem Finansowym**
**Name in English: Financial Risk Management**
**Main field of study (if applicable): Applied Mathematics**
**Specialization (if applicable): Financial and Actuarial Mathematics**
**Level and form of studies: ~~1st~~/ 2nd* level, full-time ~~/ part-time~~***
**Kind of subject: ~~obligatory~~ / optional / ~~university-wide~~***
**Subject code MAT001565**
**Group of courses YES /~~NO~~***

| | Lecture | Classes | Laboratory | Project | Seminar |
|---|---|---|---|---|---|
| Number of hours of organized classes in University (ZZU) | 30 | 30 | | | |
| Number of hours of total student workload (CNPS) | 150 | | | | |
| Form of crediting | Examination / ~~crediting with grade~~* | Examination / crediting with grade* | Examination / crediting with grade* | Examination / crediting with grade* | Examination / crediting with grade* |
| For group of courses mark (X) final course | X | | | | |
| Number of ECTS points | 5 | | | | |
| including number of ECTS points for practical (P) classes | 2 | 2 | | | |
| including number of ECTS points for direct teacher-student contact (BK) classes | 1,5 | 1,5 | | | |

*delete as applicable

**PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES**

1. Student has an elementary knowledge of financial markets and (discrete and continuous) models of financial mathematics

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**SUBJECT OBJECTIVES**

C1 Learning and mastery of key concepts and methods in the field of financial mathematics

**SUBJECT EDUCATIONAL EFFECTS**

relating to knowledge:
PEK_W01 knows the most important models and techniques of financial engineering
PEK_W02 knows the basics of stochastic and numerical modeling in financial engineering
relating to skills:
PEK_U01 can construct mathematical models used in financial engineering
relating to social competences:
PEK_K01 can by himself search for information in the literature, even in foreign languages

| PROGRAMME CONTENT | | |
|---|---|---|
| **Form of classes – lecture** | | **Number of hours** |
| Lec 1 | Fundamental theorems of asset pricing - overview | 2 |
| Lec 2 | Greek parameters, delta/gamma hedging | 2 |
| Lec 3 | Volatility modeling | 2 |
| Lec 4 | Exotic options – overview | 4 |
| Lec 5 | Stochastic control | 2 |
| Lec 6 | Risk measures and financial risk | 2 |
| Lec 7 | Portfolio pricing | 2 |
| Lec 8 | Construction of optimal portfolio, effectiveness measures of investment portfolio | 2 |
| Lec 9 | Measuring of default, asset and liability management and hedging strategies, immunization | 2 |
| Lec 10 | Credit risk management | 4 |
| Lec 11 | Operational risk management | 2 |
| Lec 12 | Time variation in risk | 2 |
| Lec 13 | Backtesting and stress testing | 2 |
| | Total hours | 30 |
| **Form of classes - class** | | **Number of hours** |
| Cl 1 | Illustration of all models.. Analytical and computer methods. Examples of pricing derivatives. | 30 |
| | Total hours | 30 |

| TEACHING TOOLS USED |
|---|
| N1. Lecture problem - traditional method.<br>N2. Problem and counting exercises.<br>N3. Consultations.<br>N4. Student's self work - preparation for exercises. |

**EVALUATION OF SUBJECT EDUCATIONAL EFFECTS ACHIEVEMENT**

| **Evaluation** (F – forming (during semester), P – concluding (at semester end) | Educational effect number | Way of evaluating educational effect achievement |
|---|---|---|
| F1 | PEK_W01<br>PEK_W02 | exam |

| | | |
|---|---|---|
| | PEK_K01 | |
| F2 | PEK_U01<br>PEK_K01 | oral responses, tests, small tests |
| P=0.5*F1+0.5*F2 | | |

**PRIMARY AND SECONDARY LITERATURE**

**PRIMARY LITERATURE:**

A. Weron, R. Weron (1998) Inżynieria finansowa, WNT
P. Jorion (2003) Financial risk manager handbook, Wiley.

**SECONDARY LITERATURE:**

P. Willmott (2006) On Quantitative Finance, Wiley.
A. J. McNeil R. Frey, P. Embrechts (2015) Quantitative Risk Management Concepts, Techniques and Tools, Princeton University Press.

**SUBJECT SUPERVISOR (NAME AND SURNAME, E-MAIL ADDRESS)**

**Prof. dr hab. Zbigniew Palmowski** (Zbigniew.Palmowski@pwr.edu.pl)

MATRIX OF CORRELATION BETWEEN EDUCATIONAL EFFECTS FOR SUBJECT **FINANCIAL RISK MANAGEMENT MAT001565** AND EDUCATIONAL EFFECTS FOR MAIN FIELD OF STUDY **APPLIED MATHEMATICS** AND SPECIALIZATION **FINANCIAL AND ACTUARIAL MATHEMATICS**

| Subject educational effect | Correlation between subject educational effect and educational effects defined for main field of study and specialization (if applicable)** | Subject objectives*** | Programme content*** | Teaching tool number*** |
|---|---|---|---|---|
| **PEK_W01 (knowledge)** | K2MST_W03<br>K2MST_fam_W01 | C1 | Lec 1-Lec 10 | 1, 3 |
| **PEK_W02** | K2MST_W09<br>K2MST_fam_W02<br>K2MST_fam_W03 | C1 | Lec 1-Lec 10 | 1, 3 |
| **PEK_U01 (skills)** | K2MST_U24<br>K2MST_U25<br>K2MST_fam_U01<br>K2MST_fam_U02<br>K2MST_fam_U03 | C1 | Cl 1 | 2, 3, 4 |
| **PEK_K01 (competences)** | K2MST_K06<br>K2MST_fam_K01<br>K2MST_fam_K02 | C1 | Lec 1-Lec 10,<br>Cl 1 | 1, 2, 3, 4 |

** - enter symbols for main-field-of-study/specialization educational effects
*** - from table above

Zał. nr 4 do ZW 64/2012

**FACULTY OF PURE AND APPLIED MATHEMATICS**
**SUBJECT CARD**

**Name in Polish: Finanse Obliczeniowe**
**Name in English: Computational Finance**
**Main field of study (if applicable): APPLIED MATHEMATICS**
**Specialization (if applicable): FINANCIAL AND ACTUARIAL MATHEMATICS, COMPUTATIONAL MATHEMATICS**
**Level and form of studies: ~~1st/~~ 2nd* level, full-time / ~~part-time~~***
**Kind of subject: ~~obligatory~~ / optional / ~~university-wide~~***
**Subject code MAT001566**
**Group of courses YES / ~~NO~~***

| | Lecture | Classes | Laboratory | Project | Seminar |
|---|---|---|---|---|---|
| Number of hours of organized classes in University (ZZU) | 30 | | 30 | | |
| Number of hours of total student workload (CNPS) | 150 | | | | |
| Form of crediting | Crediting with grade | | | | |
| For group of courses mark (X) final course | X | | | | |
| Number of ECTS points | 5 | | | | |
| including number of ECTS points for practical (P) classes | 2 | | 2 | | |
| including number of ECTS points for direct teacher-student contact (BK) classes | 1,5 | | 1,5 | | |

*delete as applicable

**PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES**

1. Student knows and can apply basic notions of financial mathematics.
2. Student knows basics of computer programming.

\

**SUBJECT OBJECTIVES**

C1 Study of concepts and acquisition of knowledge concerning algorithms and methods in computational finance
C2 Acquisition of abilities in implementing selected models and methods

**SUBJECT EDUCATIONAL EFFECTS**

relating to knowledge the student:
PEK_W01 knows basic models and algorithms used in finance
PEK_W02 has in-depth knowledge regarding numerical implementation of selected derivatives pricing techniques
relating to skills the student:
PEK_U01 can implement and apply in practice computational techniques used in finance
relating to social competences the student:
PEK_K01 can, without assistance, search for necessary information in the scientific literature

| |
|---|

| PROGRAMME CONTENT | | |
|---|---|---|
| **Form of classes - lecture** | | **Number of hours** |
| Lec1-2 | Derivatives: forwards, futures, swaps and options. Portfolio construction and pricing. Sensitivity analysis. | 4 |
| Lec3-4 | Binomial pricing: CRR, JR and „exact" trees. Hedging strategies. Trinomial trees. | 4 |
| Lec5-6 | Binomial and trinomial pricing of path dependent derivatives. | 4 |
| Lec7-8 | Monte Carlo (MC): Euler and Milstein schemes, variance reduction, correlated variates, quasi-random numbers. | 4 |
| Lec9-10 | MC pricing of American options. | 4 |
| Lec11-12 | Finite difference schemes: explicit, implicit, Crank-Nicolson, hopscotch. | 4 |
| Lec13-14 | Partial differential equations technique. | 4 |
| Lec15 | Test | 2 |
| | Total hours | **30** |

| **Form of classes - Class** | | **Number of hours** |
|---|---|---|
| La1-15 | Implementation (Matlab, R, Excel/VB, C++, Java and/or Python) of algorithms and methods discussed during lectures | 2 |
| | Total hours | **30** |

| **TEACHING TOOLS USED** |
|---|
| N1. Lecture – traditional method<br>N2. Laboratory – traditional method |

**EVALUATION OF SUBJECT EDUCATIONAL EFFECTS ACHIEVEMENT**

| **Evaluation** (F – forming (during semester), P – concluding (at semester end) | Educational effect number | Way of evaluating educational effect achievement |
|---|---|---|
| F1 | PEK_W01<br>PEK_W02 | Written test |
| F2 | PEK_U01<br>PEK_K01 | Discussions, tests, projects. |

P=0.5*F1+0.5*F2

## PRIMARY AND SECONDARY LITERATURE

**PRIMARY LITERATURE:**


[1] J. Hull (2008) Options, Futures and Other Derivatives (7th Edition), Prentice Hall
[2] J. London (2005) Modeling Derivatives in C, Wiley
[3] A. Weron, R. Weron (1998, …, 2009) Inżynieria finansowa, WNT.


**SECONDARY LITERATURE:**


[4] Z. Bodie, A. Kane, A.J. Marcus (2007) Essentials of Investments (6th ed.), McGraw-Hill
[5] M. Capiński, T. Zastawniak (2003) Mathematics for Finance: An Introduction to Financial Engineering, Springer
[6] P.Cizek, W.Härdle, R.Weron, eds. (2011) Statistical Tools for Finance and Insurance, Springer
[7] J. Franke, W. Härdle, C Hafner (2005) Introduction to Statistics of Financial Markets, Springer
[8] P. Glasserman (2004) Monte Carlo Methods in Financial Engineering, Springer
[9] P. Wilmott (2000) Paul Wilmott on Quantitative Finance, Wiley


**SUBJECT SUPERVISOR (NAME AND SURNAME, E-MAIL ADDRESS)**


**Prof. dr hab. Rafał Weron** (rafal.weron@pwr.edu.pl)

MATRIX OF CORRELATION BETWEEN EDUCATIONAL EFFECTS FOR SUBJECT
**COMPUTATIONAL FINANCE MAT001566**
AND EDUCATIONAL EFFECTS FOR MAIN FIELD OF STUDY **APPLIED MATHEMATICS**
AND SPECIALIZATION **FINANCIAL AND ACTUARIAL MATHEMATICS, COMPUTATIONAL MATHEMATICS**

| **Subject educational effect** | **Correlation between subject educational effect and educational effects defined for main field of study and specialization (if applicable)**** | **Subject objectives***** | **Programme content***** | **Teaching tool number***** |
|---|---|---|---|---|
| **PEK_W01 (knowledge)** | K2MST_W04,<br>K2MST_W09<br>K2MST_fam_W01<br>K2MST_cm_W01 | C1, C2 | Lec1-Lec15 | 1 |
| **PEK_W02** | K2MST_W08,<br>K2MST_W10<br>K2MST_fam_W02<br>K2MST_fam_W03<br>K2MST_cm _W02<br>K2MST_cm _W03 | C1, C2 | Lec1-Lec15 | 1 |
| **PEK_U01 (skills)** | K2MST_U15,<br>K2MST_U16,<br>K2MST_U17,<br>K2MST_U23<br>K2MST_U24<br>K2MST_U25<br>K2MST_fam_U01<br>K2MST_fam_U02<br>K2MST_fam_U03<br>K2MST_cm _U01<br>K2MST_cm_U02<br>K2MST_cm_U03 | C2 | Lec1-Lec15<br><br>La1-La15 | 1,2 |
| **PEK_K01 (competences)** | K2MST_K02,<br>K2MST_K06<br>K2MST_fam_K01<br>K2MST_fam_K02<br>K2MST_cm_K01<br>K2MST_cm_K02 | C1, C2 | La1-La15 | 2 |

** - enter symbols for main-field-of-study/specialization educational effects
*** - from table above

Zał. nr 4 do ZW 64/2012

**FACULTY OF PURE AND APPLIED MATHEMATICS**
**SUBJECT CARD**

**Name in Polish: MODELE UBEZPIECZENIOWE W PRZEMYŚLE**
**Name in English: Insurance models for industry**
**Main field of study (if applicable): Applied Mathematics**
**Specialization (if applicable): Financial and Actuarial Mathematics**
**Level and form of studies: ~~1st~~/ 2nd* level, full-time / ~~part-time~~***
**Kind of subject: ~~obligatory~~ / optional / ~~university-wide~~***
**Subject code MAT001567**
**Group of courses YES / ~~NO~~***

| | Lecture | Classes | Laboratory | Project | Seminar |
|---|---|---|---|---|---|
| Number of hours of organized classes in University (ZZU) | 30 | | 30 | | |
| Number of hours of total student workload (CNPS) | 150 | | | | |
| Form of crediting | Examination / ~~crediting with grade~~* | | | | |
| For group of courses mark (X) final course | X | | | | |
| Number of ECTS points | 5 | | | | |
| including number of ECTS points for practical (P) classes | 2 | | 2 | | |
| including number of ECTS points for direct teacher-student contact (BK) classes | 1,5 | | 1,5 | | |

*delete as applicable

**PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES**

1. Student knows and can apply basic concepts of the stochastic processes
2. Student knows principles of MATLAB numerical computing environment

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**SUBJECT OBJECTIVES**

C1 Study of the classical concepts and acquisition of the knowledge of insurance models in industry

**SUBJECT EDUCATIONAL EFFECTS**

relating to knowledge:
PEK_W01 knows the most important concepts of insurance models in industry
PEK_W02 knows principles of stochastic modeling in actuarial mathematics
relating to skills:
PEK_U01 can construct actuarial models, that can be applied to industry insurance
relating to social competences:
PEK_K01 can, without assistance, search for necessary information in the literature, also in foreign languages

**PROGRAMME CONTENT**

| | Form of classes - lecture | Number of hours |
|---|---|---|
| Lec 1 | Types of insurance policies in industry. Solvency II in Non-Life Insurance. | 2 |
| Lec 2 | Premium principles, risk measures. | 2 |

| | | |
|---|---|---|
| Lec 3 | Franchises and their types. Pricing of net premiums with franchise. | 2 |
| Lec 4 | Individual risk model. | 2 |
| Lec 5 | Approximations for total loss in individual risk model | 2 |
| Lec 6 | Collective risk model. Frequency and severity distributions of claims. Parameters and distributions of aggregate claim amount. | 2 |
| Lec 7 | Compound Poisson model. Practical consequences of the theorem on the sum of compund Poisson risk. | 2 |
| Lec 8 | The (a,b) class of distribution. Mixed Poisson model. | 2 |
| Lec 9 | Risk proces. The adjustment coefficient. The probability of ruin. | 4 |
| Lec 10 | Distribution of the maximal aggregate coefficient and ruin probability. Pollaczek-Khinchin formula. | 3 |
| Lec 11 | Approximations of ruin probability in finite and infinite time horizon | 2 |
| Lec 12 | System Bonus-Malus | 2 |
| Lec 13 | Credibility theory | 3 |
| | Total hours | **30** |

| **Form of classes - laboratory** | | **Number of hours** |
|---|---|---|
| Lab 1 | Solving of problems illustrating theory given in the lectures | 30 |
| | Total hours | **30** |

**TEACHING TOOLS USED**

N1. Lecture – traditional method
N2. Computer laboratory with MATLAB numerical computation environment
N3. Consultations
N4. Student's self-work – preparation for the laboratory

**EVALUATION OF SUBJECT EDUCATIONAL EFFECTS ACHIEVEMENT**

| **Evaluation** (F – forming (during semester), P – concluding (at semester end) | Educational effect number | Way of evaluating educational effect achievement |
|---|---|---|
| F1 | PEK_W01<br>PEK_W02<br>PEK_K01 | exam |
| F2 | PEK_U01<br>PEK_K01 | oral presentations, tests |
| P=0.5*F1+0.5*F2 | | |

**PRIMARY AND SECONDARY LITERATURE**

**PRIMARY LITERATURE:**

[1] N. L. Bowers i inni, Actuarial Mathematics, The Society of Actuaries, Itasca, Illinois 1997
[2] P. Cizek, W. Haerdle, R. Weron (red.), Statistical tools for finance and insurance, Springer, Berlin, 2011

**SECONDARY LITERATURE:**

[1] E.Banks, Alternative risk transfer, Wiley, 2003
[2] S. A. Klugman, H. H. Panjer, G. E. Willmot, Loss Models: From Data to Decisions, Wiley, 2012
[3] H. H. Panjer, G. E. Willmot, Insurance risk models, Society of Actuaries, 1992

**SUBJECT SUPERVISOR (NAME AND SURNAME, E-MAIL ADDRESS)**

**Dr hab. inż. Krzysztof Burnecki, prof. nadzw.** (Krzysztof.Burnecki@pwr.edu.pl)
**Dr hab. inż. Agnieszka Wyłomańska, prof. nadzw.** (Agnieszka.Wylomanska@pwr.edu.pl)

MATRIX OF CORRELATION BETWEEN EDUCATIONAL EFFECTS FOR SUBJECT **INSURANCE MODELS FOR INDUSTRY MAT001567** AND EDUCATIONAL EFFECTS FOR MAIN FIELD OF STUDY **APPLIED MATHEMATICS** AND SPECIALIZATION **FINANCIAL AND ACTUARIAL MATHEMATICS**

| **Subject educational effect** | **Correlation between subject educational effect and educational effects defined for main field of study and specialization (if applicable)**** | **Subject objectives***** | **Programme content***** | **Teaching tool number***** |
|---|---|---|---|---|
| **PEK_W01 (knowledge)** | K2MST_W03<br>K2MST_fam_W01<br>K2MST_fam_W02 | C1 | Lec 1- Lec 12 | 1,3 |
| **PEK_W02** | K2MST_W09<br>K2MST_fam_W03 | C1 | Lec 1- Lec 12 | 1,3 |
| **PEK_U01 (skills)** | K2MST_U15<br>K2MST_U24<br>K2MST_U25<br>K2MST_fam_U01<br>K2MST_fam_U02<br>K2MST_fam_U03 | C1 | Lab 1 | 2,3,4 |
| **PEK_K01 (competences)** | K2MST_K06<br>K2MST_fam_K01<br>K2MST_fam_K02 | C1 | Lec 1- Lec 12,<br>Lab 1 | 1,2,3,4 |

** - enter symbols for main-field-of-study/specialization educational effects
*** - from table above

**FACULTY OF PURE AND APPLIED MATHEMATICS**
**SUBJECT CARD**

**Name in Polish: REZERWY W UBEZPIECZENIACH ŻYCIOWYCH I MAJĄTKOWYCH**
**Name in English: Reserves in life and non-life insurance**
**Main field of study (if applicable): Applied Mathematics**
**Specialization (if applicable): Financial and Actuarial Mathematics**
**Level and form of studies: ~~1st~~/ 2nd* level, full-time / ~~part-time~~***
**Kind of subject: ~~obligatory~~ / optional / ~~university-wide~~***
**Subject code MAT001568**
**Group of courses YES / ~~NO~~***

| | Lecture | Classes | Laboratory | Project | Seminar |
|---|---|---|---|---|---|
| Number of hours of organized classes in University (ZZU) | 30 | 30 | | | |
| Number of hours of total student workload (CNPS) | 150 | | | | |
| Form of crediting | Examination / ~~crediting with grade*~~ | Examination / crediting with grade* | Examination / crediting with grade* | Examination / crediting with grade* | Examination / crediting with grade* |
| For group of courses mark (X) final course | X | | | | |
| Number of ECTS points | 5 | | | | |
| including number of ECTS points for practical (P) classes | 2 | 2 | | | |
| including number of ECTS points for direct teacher-student contact (BK) classes | 1.5 | 1.5 | | | |

*delete as applicable

**PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES**

1. Student knows and can apply basic concepts of the probability theory
2. Student knows and can apply basic concepts of actuarial mathematics including life and non-life insurance.

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**SUBJECT OBJECTIVES**

C1 Study of the classical concepts and acquisition of the knowledge of reserving in life and non-life insurance

**SUBJECT EDUCATIONAL EFFECTS**

relating to knowledge:
PEK_W01 knows the most important concepts of reserving in life and non-life insurance mathematics
PEK_W02 knows principles of stochastic modeling in life and non-life insurance mathematics
relating to skills:
PEK_U01 can construct mathematical models used in reserving in life and non-life insurance mathematics
relating to social competences:
PEK_K01 can, without assistance, search for necessary information in the literature, also in foreign languages

| PROGRAMME CONTENT | | |
|---|---|---|
| **Form of classes - lecture** | | **Number of hours** |
| Lec 1 | Introduction to the course, survey over provision types. | 2 |
| Lec 2 | Net reserves in life insurance. | 4 |
| Lec 3 | Decomposition of the loss random variable (Hattendorff's theorem). | 2 |
| Lec 4 | Technical gain. | 2 |
| Lec 5 | Gross reserves in life insurance, Zillmer's reserve | 2 |
| Lec 6 | Multiple decrement model: net premiums and reserves | 4 |
| Lec 7 | Multiple life insurance: net premiums and reserves | 6 |
| Lec 8 | Provisions in non-life insurance, including loss data triangles, chain-ladder method, IBNR, premium reserve | 4 |
| Lec 9 | Solvency II - technical provisions, best estimate, risk margin, technical provisions for accounting purposes | 4 |
| | Total hours | **30** |
| **Form of classes - class** | | **Number of hours** |
| Cl 1 | Solving of problems illustrating theory given in the lectures, solving of problems from actuarial exams | 30 |
| | Total hours | **30** |

**TEACHING TOOLS USED**

N1. Lecture – traditional method.
N2. Problem-solving classes.
N3. Consultations.
N4. Student's self-work – preparation for the classes.

**EVALUATION OF SUBJECT EDUCATIONAL EFFECTS ACHIEVEMENT**

| **Evaluation** (F – forming (during semester), P – concluding (at semester end) | Educational effect number | Way of evaluating educational effect achievement |
|---|---|---|
| F1 | PEK_W01<br>PEK_W02<br>PEK_K01 | exam |
| F2 | PEK_U01<br>PEK_K01 | oral presentations, tests |
| P=0.5*F1+0.5*F2 | | |

**PRIMARY AND SECONDARY LITERATURE**

**PRIMARY LITERATURE:**


C1 N. L. Bowers at al „Actuarial Mathematics", The Society of Actuaries, Itasca, Illinois 1997.
C2 H. U. Gerber „Life insurance mathematics", Springer-Verlag, Berlin 1997.
C3 M. J. Goovaerts et al. „Effective Actuarial Methods"; North Holland, 1990.
C4 R. Kaas et al. „Modern Actuarial Risk Theory"; Kluwer Academic Publishers, 2001.


**SUBJECT SUPERVISOR (NAME AND SURNAME, E-MAIL ADDRESS)**


**Dr hab. inż. Krzysztof Burnecki, prof. nadzw.** (Krzysztof.Burnecki@pwr.edu.pl)
**Dr inż. Marek Teuerle** (Marek.Teuerle@pwr.edu.pl)

MATRIX OF CORRELATION BETWEEN EDUCATIONAL EFFECTS FOR SUBJECT **RESERVES IN LIFE AND NONLIFE INSURANCE MAT001568** AND EDUCATIONAL EFFECTS FOR MAIN FIELD OF STUDY **APPLIED MATHEMATICS** AND SPECIALIZATION **FINANCIAL AND ACTUARIAL MATHEMATICS**

| **Subject educational effect** | **Correlation between subject educational effect and educational effects defined for main field of study and specialization (if applicable)**** | **Subject objectives***** | **Programme content***** | **Teaching tool number***** |
|---|---|---|---|---|
| **PEK_W01 (knowledge)** | K2MST_W03<br>K2MST_fam_W01 | C1 | Lec 1- Lec 8 | 1,3 |
| **PEK_W02** | K2MST_W09<br>K2MST_fam_W02<br>K2MST_fam_W03 | C1 | Lec 1- Lec 8 | 1,3 |
| **PEK_U01 (skills)** | K2MST_U15<br>K2MST_U24<br>K2MST_U25<br>K2MST_fam_U01<br>K2MST_fam_U02<br>K2MST_fam_U03 | C1 | Cl 1 | 2,3,4 |
| **PEK_K01 (competences)** | K2MST_K06<br>K2MST_fam_K01<br>K2MST_fam_K02 | C1 | Lec 1- Lec 8,<br>Cl 1 | 1,2,3,4 |

** - enter symbols for main-field-of-study/specialization educational effects

*** - from table above

Zał. nr 4 do ZW 64/2012

**FACULTY OF PURE AND APPLIED MATHEMATICS**
**SUBJECT CARD**

**Name in Polish: ZARZĄDZANIE RYZYKIEM W UBEZPIECZENIACH**
**Name in English: Risk management in insurance**
**Main field of study (if applicable): Applied Mathematics**
**Specialization (if applicable): Financial and Actuarial Mathematics**
**Level and form of studies: ~~1st~~/ 2nd* level, full-time / ~~part-time~~***
**Kind of subject: ~~obligatory~~ / optional / ~~university-wide~~***
**Subject code MAT001569**
**Group of courses YES / ~~NO~~***

| | Lecture | Classes | Laboratory | Project | Seminar |
|---|---|---|---|---|---|
| Number of hours of organized classes in University (ZZU) | 30 | | | 30 | |
| Number of hours of total student workload (CNPS) | 150 | | | | |
| Form of crediting | Examination / ~~crediting with grade*~~ | Examination / crediting with grade* | Examination / crediting with grade* | Examination / crediting with grade* | Examination / crediting with grade* |
| For group of courses mark (X) final course | X | | | | |
| Number of ECTS points | 5 | | | | |
| including number of ECTS points for practical (P) classes | 2 | | | 2 | |
| including number of ECTS points for direct teacher-student contact (BK) classes | 1.5 | | | 1.5 | |

*delete as applicable

**PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES**

1. Student knows and can apply basic concepts of the probability theory
2. Student knows and can apply basic concepts of actuarial mathematics including life and non-life insurance.
3. Student knows and can apply basic concepts of reserving in life and non-life insurance mathematics

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**SUBJECT OBJECTIVES**

C1 Study of the classical concepts and acquisition of the knowledge of risk management in life and non-life insurance

**SUBJECT EDUCATIONAL EFFECTS**

relating to knowledge:

PEK_W01 knows the most important concepts of risk management in life and non-life insurance mathematics

PEK_W02 knows principles of stochastic modeling in risk management

relating to skills:

PEK_U01 can construct mathematical models and apply methods used in risk management in life and non-life insurance mathematics

relating to social competences:

PEK_K01 can, without assistance, search for necessary information in the literature, also in foreign languages

**PROGRAMME CONTENT**

| **Form of classes - lecture** | | **Number of hours** |
|---|---|---|
| Lec 1 | Risk management in insurance, actuarial function, risk management function | 2 |
| Lec 2 | Capital management, risk appetite, risk measures (including RAROC, RORAC) | 2 |
| Lec 3 | Solvency II: capital requirements, standard formula, internal models, risk categories | 6 |
| Lec 4 | Profitability and risk exposure tests, monitoring of actuarial assumptions or parameters | 4 |
| Lec 5 | Risk exposure reduction methods, methods and instruments of risk transfer including alternative risk transfers (ART) | 4 |
| Lec 6 | Proportional and non-proportional reinsurance as method of risk exposure reduction | 4 |
| Lec 7 | Actuarial pricing in life and non-life insurance, risk factors. | 2 |
| Lec 8 | Application of derivatives in insurance | 3 |
| Lec 9 | Pricing of catastrophe bonds. | 3 |
| | Total hours | **30** |

| **Form of classes - project** | | **Number of hours** |
|---|---|---|
| Pr 1 | Preparation and presentations of projects illustrating theory given in the lectures. | 30 |
| | Total hours | **30** |

**TEACHING TOOLS USED**

N1. Lecture – traditional method and presentations
N2. Student partial project presentation and final presentation
N3. Consultations
N4. Student's self-work – work on the project development

**EVALUATION OF SUBJECT EDUCATIONAL EFFECTS ACHIEVEMENT**

| **Evaluation** (F – forming (during semester), P – | Educational effect number | Way of evaluating educational effect achievement |
|---|---|---|

| | | |
|---|---|---|
| concluding (at semester end) | | |
| F1 | PEK_W01<br>PEK_W02<br>PEK_K01 | exam |
| F2 | PEK_U01<br>PEK_K01 | Partial project presentations, final project presentation |
| P=0.5*F1+0.5*F2 | | |

**PRIMARY AND SECONDARY LITERATURE**

**PRIMARY LITERATURE:**


[1] N. L. Bowers i inni, „Actuarial mathematics", The Society of Actuaries, Itasca, Illinois, 1997.
[2] H. U. Gerber, „Life insurance mathematics", Springer-Verlag, Berlin, 1997.
[3] C. D. Daykin i inni, „Practical risk theory for actuaries", Chapman & Hall, London, 1996.
[4] R. Kaas, M. Gooveaerts, J. Dhaene, M. Denuit „Modern actuarial Risk Theory", Springer-Verlag, Berlin Heidelberg, 2008.
[5] P.M. Booth, R. G. Chadburn, S. Haberman et al. „Modern actuarial theory and practice" 2nd ed.; Chapman & Hall, 2005
[6] M. V. Wüthrich, M. Merz,"Financial Modeling, Actuarial Valuation and Solvency in Insurance", Springer-Verlag Berlin Heidelberg, 2013.
[7] DIRECTIVE 2009/138/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 25 November 2009 on the taking-up and pursuit of the business of Insurance and Reinsurance (Solvency II)


**PRIMARY LITERATURE:**


[1] L. Hölscher, P. Harding, G. M. Becker, „ Financing the Embedded Value of Life Insurance Portfolios", HfB – Working Paper Series, 2005.


**SUBJECT SUPERVISOR (NAME AND SURNAME, E-MAIL ADDRESS)**


**Dr inż. Marek Teuerle** (Marek.Teuerle@pwr.edu.pl)

**Dr hab. inż. Krzysztof Burnecki, prof. nadzw.** (Krzysztof.Burnecki@pwr.edu.pl)

MATRIX OF CORRELATION BETWEEN EDUCATIONAL EFFECTS FOR SUBJECT **ACTUARIAL METHODS IN RISK MANAGEMENT MAT001569** AND EDUCATIONAL EFFECTS FOR MAIN FIELD OF STUDY **APPLIED MATHEMATICS** AND SPECIALIZATION **FINANCIAL AND ACTUARIAL MATHEMATICS**

| Subject educational effect | Correlation between subject educational effect and educational effects defined for main field of study and specialization (if applicable)** | Subject objectives*** | Programme content*** | Teaching tool number*** |
|---|---|---|---|---|
| **PEK_W01 (knowledge)** | K2MST_W03<br>K2MST_fam_W01 | C1 | Lec 1- Lec 9 | 1,3 |
| **PEK_W02** | K2MST_W09<br>K2MST_fam_W02<br>K2MST_fam_W03 | C1 | Lec 1- Lec 9 | 1,3 |
| **PEK_U01 (skills)** | K2MST_U15<br>K2MST_U24<br>K2MST_U25<br>K2MST_fam_U01<br>K2MST_fam_U02<br>K2MST_fam_U03 | C1 | Pr 1 | 2,3,4 |
| **PEK_K01 (competences)** | K2MST_K06<br>K2MST_fam_K01<br>K2MST_fam_K02 | C1 | Lec 1- Lec 9,<br>Pr 1 | 1,2,3,4 |

** - enter symbols for main-field-of-study/specialization educational effects

*** - from table above

Zał. nr 4 do ZW 64/2012

**FACULTY OF PURE AND APPLIED MATHEMATICS**
**SUBJECT CARD**
**Name in Polish: METODY NUMERYCZNE W RÓWNANIACH RÓŻNICZKOWYCH**
**Name in English: Numerical methods in differential equations**
**Main field of study (if applicable): APPLIED MATHEMATICS**
**Specialization (if applicable): Mathematics for Industry and Commerce**
**Level and form of studies: ~~1st/~~ 2nd* level, full-time / ~~part-time~~***
**Kind of subject: ~~obligatory~~ / optional / ~~university-wide~~***
**Subject code MAT001570**
**Group of courses YES / ~~NO~~***

| | Lecture | Classes | Laboratory | Project | Seminar |
|---|---|---|---|---|---|
| Number of hours of organized classes in University (ZZU) | 30 | | 30 | | |
| Number of hours of total student workload (CNPS) | 150 | | | | |
| Form of crediting | Examination / crediting with grade* | Examination / crediting with grade* | Examination / crediting with grade* | Examination / crediting with grade* | Examination / crediting with grade* |
| For group of courses mark (X) final course | X | | | | |
| Number of ECTS points | 5 | | | | |
| including number of ECTS points for practical (P) classes | 2 | | 2 | | |
| including number of ECTS points for direct teacher-student contact (BK) classes | 1,5 | | 1,5 | | |

*delete as applicable

**PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES**

1. Student has basic knowledge and abilities on mathematical analysis.
2. Student has basic knowledge concerning programming environments: Matlab/Mathematica/Mapple.

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**SUBJECT OBJECTIVES**

C1 Study of basic notions and knowledge in the area of numerical methods applied in differential equations
C2 Study of basic numerical techniques used in discretization of differentia equations.
C3 Acquisition of basis abilities in construing and analyzing difference schemes for differential equations

**SUBJECT EDUCATIONAL EFFECTS**

relating to knowledge student:

PEK_W01 knows the most important numerical techniques used in solving problems for differential equations

PEK_W02 knows bases of construing own numerical schemes

relating to skills student:

PEK_U01 is able to analyze basic problems in differential equations with respect to application of suitable approximate methods

PEK_U02 is able to construct mathematical models used in concrete applications of mathematics, based on differential equations and their discrete forms.

…

relating to social competences:

PEK_K01 can, without assistance, search for necessary information in the literature

PEK_K02 understands necessity of systematic and individual work on the material of the course.

| **PROGRAMME CONTENT** | | |
|---|---|---|
| **Form of classes - lecture** | | **Number of hours** |
| Lec 1 | Recalling basic facts of theory of ordinary differential equations. | 2 |
| Lec 2 | Explicit and implicit Euler method of approximate solving of ordinary differential equations and their systems. | 2 |
| Lec 3 | Runge-Kutta type methods and other schemes of approximation of ordinary differential equations and their systems. | 2 |
| Lec 4 | Multi-step methods, stability of numerical methods. Stiff problems. | 2 |
| Lec 5 | Methods of approximation of boundary value problems for second order ordinary differentia equations: shooting methods and difference methods. | 2 |
| Lec 6 | Methods of approximation of boundary value problems for second order ordinary differentia equations: Ritz-Galerkin method. | 2 |
| Lec 7 | Difference methods for first order partial differentia equations. CFL condition. | 2 |
| Lec 8 | Recalling basic facts of theory of second order partial differential equations. | 2 |
| Lec 9 | Difference approximation of elliptic boundary value problems on the plane. | 2 |
| Lec 10 | Variational formulation of boundary value problems for elliptic type equations. | 2 |
| Lec 11 | Ritz-Galerkin and finite element methods for elliptic problems. | 2 |
| Lec 12 | Difference methods for parabolic problems. Explicit and implicit schemes for heat conduction equation. | 2 |
| Lec 13 | Stability of approximate method. Cranck-Nicholson scheme for equations of parabolic type. | 2 |
| Lec 14 | Difference methods for the vibrating string problem and other | 4 |

| | | |
|---|---|---|
| | hyperbolic problems. | |
| | Total hours | 30 |

| Form of classes - laboratory | | Number of hours |
|---|---|---|
| Lab 1 | Computer construction of solution of ordinary differentia equations. | 4 |
| Lab 2 | Practical verifying of efficacy of automatic exactness control. | 2 |
| Lab 3 | Visualization and comparison of usefulness of various methods. | 4 |
| Lab 4 | Algorithms for numerical methods of solution of one-dimensional boundary value problems for elliptic equations. | 4 |
| Lab 5 | Discretisation of hyperbolic first order problems. Conditions of stability and convergence of approximate methods. | 4 |
| Lab 6 | Discretization of two-dimensional boundary value problem for elliptic equations. | 4 |
| Lab 7 | Difference schemes of approximation of one-dimensional parabolic equation. | 4 |
| Lab 8 | Difference method of discretization of the vibrating string equation. | 4 |
| | Total hours | |

| TEACHING TOOLS USED |
|---|
| N1. Lecture – traditional method.<br>N2. Problem and computing laboratory – traditional and using computers method.<br>N3. Consultations.<br>N4. Student's personal work – preparation for the laboratory. |

**EVALUATION OF SUBJECT EDUCATIONAL EFFECTS ACHIEVEMENT**

| **Evaluation** (F – forming (during semester), P – concluding (at semester end) | Educational effect number | Way of evaluating educational effect achievement |
|---|---|---|
| F1 | PEK_W01<br>PEK_W02<br>PEK_K01 | Presentation of given problems. |
| F2 | PEK_U01<br>PEK_U02<br>PEK_K01 | Oral presentations, tests. |
| P=0.5*F1+0.5*F2 | | |

| PRIMARY AND SECONDARY LITERATURE |
|---|

**PRIMARY LITERATURE:**

[1] Richard L. Burden, J. Douglas Faires, Numerical Analysis.
[2] R. M. Mattheij, S. W. Rienstra, J.H.M. ten Thije Boonkkamp, Partial differential equations. Modeling, analysis and computations.
[3] Stig Larsson, Vidar Thomee, Partial differential equations with numerical methods.

**SECONDARY LITERATURE**

[1] L. Lapidus, G. F. Pinder, Numerical solution of partial differential equations in science and engineering, John Wiley & Sons, 1998
[2] R. J. Le Vegue, Numerical Methods for conservation laws, Birkhauser, Basel 1990
[3] J. W. Thomas, Numerical partial differential equations: conservation laws and elliptic equations, Springer, New York 1999

**SUBJECT SUPERVISOR (NAME AND SURNAME, E-MAIL ADDRESS)**

**Dr hab. Wojciech Mydlarczyk** (Wojciech.Mydlarczyk@pwr.edu.pl)

MATRIX OF CORRELATION BETWEEN EDUCATIONAL EFFECTS FOR SUBJECT **NUMERICAL METHODS IN DIFFERENTIAL EQUATIONS MAT001570** AND EDUCATIONAL EFFECTS FOR MAIN FIELD OF STUDY MATHEMATICS AND SPECIALIZATION **MATHEMATICS FOR INDUSTRY AND COMMERCE**

| Subject educational effect | Correlation between subject educational effect and educational effects defined for main field of study and specialization (if applicable)** | Subject objectives*** | Programme content*** | Teaching tool number*** |
|---|---|---|---|---|
| **PEK_W01 (knowledge)** | K2MST_W03<br>K2MST_mic_W01 | C1-C3 | Lec1- Lec14 | 1,3 |
| **PEK_W02** | K2MST_W10<br>K2MST_mic_W02<br>K2MST_mic_W03 | C1-C3 | Lec1- Lec14 | 1,3 |
| **PEK_U01 (skills)** | K2MST_U15,<br>K2MST_U24<br>K2MST_U25<br>K2MST_U28<br>K2MST_U29<br>K2MST_mic_U01 | C1-C3 | La1-La8 | 2,3,4 |
| **PEK_U02** | K2MST_U16<br>K2MST_mic_U02<br>K2MST_mic_U03 | C1-C3 | La1-La8 | 2,3,4 |
| **PEK_K01 (competences)** | K2MST_K06<br>K2MST_mic_K01 | C1-C3 | Lec1- Lec14,<br>La1-La8 | 1,2,3,4 |
| **PEK_K02** | K2MST_K01<br>K2MST_mic_K02 | C1-C3 | Lec1- Lec14,<br>La1-La8 | 1,2,3,4 |

** - enter symbols for main-field-of-study/specialization educational effects

*** - from table above

**FACULTY OF PURE AND APPLIED MATHEMATICS**
**SUBJECT CARD**

**Name in Polish WSTĘP DO STOSOWANEJ DYNAMIKI CIECZY**
**Name in English INTRODUCTION TO APPLIED FLUID DYNAMICS**
**Main field of study (if applicable): APPLIED MATHEMATICS**
**Level and form of studies: ~~1st~~/ 2nd* level, full-time / ~~part-time*~~**
**Kind of subject: ~~obligatory~~ / optional /~~ university-wide*~~**
**Subject code MAT001571**
**Group of courses YES / ~~NO~~***

| | Lecture | Classes | Laboratory | Project | Seminar |
|---|---|---|---|---|---|
| Number of hours of organized classes in University (ZZU) | 30 | | | 30 | |
| Number of hours of total student workload (CNPS) | 150 | | | | |
| Form of crediting | Examination / ~~crediting with grade*~~ | | | | |
| For group of courses mark (X) final course | X | | | | |
| Number of ECTS points | 5 | | | | |
| including number of ECTS points for practical (P) classes | 2 | | | 2 | |
| including number of ECTS points for direct teacher-student contact (BK) classes | 1,5 | | | 1,5 | |

*delete as applicable

**PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES**

[1] Student has the standard knowledge of the classical concepts , theorems and methods of real and complex analysis
[2] Student has basic knowledge of concepts and methods of the ordinary differential equations

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**SUBJECT OBJECTIVES**

[1] Study of the advanced methods of mathematical analysis in mathematical model ling of the dynamics fluid phenomena.

**SUBJECT EDUCATIONAL EFFECTS**

relating to knowledge:

PEK_W01 knows advanced theorems of the Real and complex analysis related to the fluid dynamics

PEK_W02 has advanced knowledge concerning mathematical analysis: is able to understand formulations of the studied problems related to the fluid dynamics

relating to skills:

PEK_U01 can construct mathematical models applied in the fluid dynamics

relating to social competences:

| |
|---|
| PEK_K01 can, without assistance, search for necessary information in the literature, also in foreign languages |

**PROGRAMME CONTENT**

| Form of classes - lecture | | Number of hours |
|---|---|---|
| Lec 1 | Reminder of the vector analysis elements | 2 |
| Lec 2 | Reminder of the vector analysis elements | 2 |
| Lec 3 | Reminder of the complex analysis elements | 2 |
| Lec 4 | Conformal mappings | 2 |
| Lec 5 | Laws of conservation | 2 |
| Lec 6 | Equations of motion for an ideal fluid | 2 |
| Lec 7 | Elementary viscous flow | 2 |
| Lec 8 | Waves | 2 |
| Lec 9 | Waves | 2 |
| Lec 10 | Shock waves modelling | 2 |
| Lec 11 | Classical aerofoil theory | 2 |
| Lec 12 | Classical aerofoil theory | 2 |
| Lec 13 | Nonlinear models in diffusion phenomena | 2 |
| Lec 14 | Boundary layers | 2 |
| Lec 15 | Computational fluid dynamics (CFD) | 2 |
| | Total hours | **30** |

| Form of classes - project | | Number of hours |
|---|---|---|
| Pr 1 | Preparation and presentations of projects illustrating theory given in the lectures. | 30 |
| | Total hours | **30** |

**TEACHING TOOLS USED**

N1. Lecture – traditional method and presentations
N2. Student partial project presentation and final presentation
N3. Consultations
N4. Student's self work – work on the project development

**EVALUATION OF SUBJECT EDUCATIONAL EFFECTS ACHIEVEMENT**

| **Evaluation** (F – forming (during semester), P – concluding (at semester end) | Educational effect number | Way of evaluating educational effect achievement |
|---|---|---|
| F1 | PEK_W01<br>PEK_W02<br>PEK_K01 | exam |
| F2 | PEK_U01 | Partial project presentations, |

| | | |
|---|---|---|
| | PEK_K01 | final project presentation |
| C P==0.5*F1+0.5*F2 | | |

**PRIMARY AND SECONDARY LITERATURE**

**PRIMARY LITERATURE:**

C5 B. J. Acheson, Elementary Fluid Dynamics.
C6 H.Ockendon, A.B.Tayler, Inviscid Fluid Flows.

**SECONDARY LITERATURE:**

[1] J.D. Logan, Applied Mathematics. A Contemporary Approach.
[2] K. Ericsson, D. Estep, P. Hansbo, C. Johnson, Computational Differential Equations

**SUBJECT SUPERVISOR (NAME AND SURNAME, E-MAIL ADDRESS)**

**Prof. dr hab. Wojciech Okrasiński** (Wojciech.Okrasinski@pwr.edu.pl)
**Dr inż. Łukasz Płociniczak** (Lukasz.Plociniczak@pwr.edu.pl)

MATRIX OF CORRELATION BETWEEN EDUCATIONAL EFFECTS FOR SUBJECT **INTRODUCTION TO APPLIED FLUID DYNAMICS MAT001571** AND EDUCATIONAL EFFECTS FOR MAIN FIELD OF STUDY **APPLIED MATHEMATICS** AND SPECIALIZATION **MATHEMATICS FOR INDUSTRY AND COMMERCE**

| Subject educational effect | Correlation between subject educational effect and educational effects defined for main field of study and specialization (if applicable)** | Subject objectives*** | Programme content*** | Teaching tool number*** |
|---|---|---|---|---|
| **PEK_W01 (knowledge)** | K2MST_W03<br>K2MST_mic_W01 | C1 | Lec1-Lec15 | 1,3 |
| **PEK_W02** | K2MST_W06<br>K2MST_mic_W02<br>K2MST_mic_W03 | C1 | Lec1-Lec15 | 1,3 |
| **PEK_U01 (skills)** | K2MST_U15<br>K2MST_U24<br>K2MST_U25<br>K2MST_mic_U01<br>K2MST_mic_U02<br>K2MST_mic_U03 | C1 | Pr 1 | 2,3,4 |
| **PEK_K01 (competences)** | K2MST_K06<br>K2MST_mic_K01<br>K2MST_mic_K02 | C1 | Lec1-Lec15<br>Pr 1 | 1,2,3,4 |

** - enter symbols for main-field-of-study/specialization educational effects
*** - from table above

**FACULTY OF PURE AND APPLIED MATHEMATICS**
**SUBJECT CARD**

**Name in Polish METODY PERTURBACYJNE**
**Name in English Perturbation Methods**
**Main field of study (if applicable): APPLIED MATHEMATICS**
**Specialization (if applicable): Mathematics for Industry and Commerce**
**Level and form of studies: ~~1st/~~ 2nd* level, full-time ~~/ part-time*~~**
**Kind of subject: ~~obligatory /~~ optional ~~/ university-wide~~***
**Subject code MAT001572**
**Group of courses YES / ~~NO~~***

| | Lecture | Classes | Laboratory | Project | Seminar |
|---|---|---|---|---|---|
| Number of hours of organized classes in University (ZZU) | 30 | | 30 | | |
| Number of hours of total student workload (CNPS) | 150 | | | | |
| Form of crediting | ~~Examination /~~ crediting with grade* | ~~Examination / crediting with grade*~~ | ~~Examination / crediting with grade*~~ | ~~Examination / crediting with grade*~~ | ~~Examination / crediting with grade*~~ |
| For group of courses mark (X) final course | X | | | | |
| Number of ECTS points | 5 | | | | |
| including number of ECTS points for practical (P) classes | 2 | | 2 | | |
| including number of ECTS points for direct teacher-student contact (BK) classes | 1,5 | | 1,5 | | |

*delete as applicable

**MathematicsPREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES**

The student knows and he is able to use the classic concepts and theorems of mathematical analysis

Second He knows and is able to apply basic concepts and methods in the field of differential equations

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**SUBJECT OBJECTIVES**

C1 Understanding the basic concepts and mastering the basic techniques used in the methods of perturbation**Mathematics**

**SUBJECT EDUCATIONAL EFFECTS**

relating to knowledge:

PEK_W01 has in-depth knowledge of the methods of perturbation

PEK_W02 know the numerical methods used to find approximate solutions mathematical problems (for example, differential equations) pose in the field of applied domain

relating to skills:

PEK_U01 can construct mathematical models used in concrete advanced applications of mathematics

relating to social competences:

PEK_K01 can benefit from the scientific literature in English, including reaching the source materials and make them review

**PROGRAMME CONTENT**

| **Form of classes - lecture** | | **Number of hours** |
|---|---|---|
| Lec 1 | Examples of problems leading to perturbation method | 2 |
| Lec 2 | Regular perturbation method | 2 |
| Lec 3 | Poincare-Lindstedt method | 2 |
| Lec 4 | Asymptotes | 2 |
| Lec 5 | Unreliability of the regular perturbation method | 2 |
| Lec 6 | Singular perturbation method | 2 |
| Lec 7 | The inner and outer approximations | 2 |
| Lec 8 | Analysis of shoreline layer | 2 |
| Lec 9 | Inner approximation and scaling | 2 |
| Lec 10 | Combining internal and external approximation | 2 |
| Lec 11 | Uniform approximation | 2 |
| Lec 12 | Examples of uniform approximation | 2 |
| Lec 13 | Phenomena associated with the film edge | 2 |
| Lec 14 | Partial differential equations and perturbation methods | 2 |
| Lec 15 | Algebraic equations and perturbation methods | 2 |
| | Total hours | 30 |

| **Form of classes - laboratory** | | **Number of hours** |
|---|---|---|
| Lab 1 | Solving problems illustrating a lecture given theory using MATLAB | 30 |
| | Total hours | 30 |

**TEACHING TOOLS USED**

N1. Lecture - traditional method

N2. Computer laboratory

N3. Individual consultation

N4. Student's own work - to prepare for the lab

**EVALUATION OF SUBJECT EDUCATIONAL EFFECTS ACHIEVEMENT**

| **Evaluation** (F – forming (during semester), P – concluding (at semester end) | Educational effect number | Way of evaluating educational effect achievement |
|---|---|---|
| F1 | PEK_W1<br>PEK_W2 | test |
| F2 | PEK_U1<br>PEK-K1 | verbal responses, short tests, tests, reports |
| C=0.5*F1+0.5*F2 | | |

| **PRIMARY AND SECONDARY LITERATURE** |
|---|
| **PRIMARY LITERATURE:**<br>[1] E. J. Hinch, Perturbation Methods.<br>[2] J. David Logan, Applied Mathematics.<br>**SECONDARY LITERATURE:**<br>[1] C.C.Lin, L.A.Segel, Mathematics Applied to Deterministic Problems in the Natural Sciencec, SIAM 1988 |
| **SUBJECT SUPERVISOR (NAME AND SURNAME, E-MAIL ADDRESS)** |
| **Prof. dr hab. Wojciech Okrasiński** (Wojciech.Okrasinski@pwr.edu.pl) |

MATRIX OF CORRELATION BETWEEN EDUCATIONAL EFFECTS FOR SUBJECT **Perturbation Methods MAT001572** AND EDUCATIONAL EFFECTS FOR MAIN FIELD OF STUDY APPLIED MATHEMATICS AND SPECIALIZATION **MATHEMATICS FOR INDUSTRY AND COMMERCE**

| Subject educational effect | Correlation between subject educational effect and educational effects defined for main field of study and specialization (if applicable)** | Subject objectives*** | Programme content*** | Teaching tool number*** |
|---|---|---|---|---|
| **PEK_W01 (knowledge)** | K2MST_W04<br>K2MST_mic_W01 | C1 | Lec1-Lec15 | 1, 3 |
| **PEK_W02** | K2MST_W10<br>K2MST_mic_W02<br>K2MST_mic_W03 | C1 | Lec1-Lec15 | 1, 3 |
| **PEK_U01 (skills)** | K2MST_U15<br>K2MST_mic_U01<br>K2MST_mic_U02<br>K2MST_mic_U03 | C1 | Lab1 | 2, 3, 4 |
| **PEK_K01 (competences)** | K2MST_K06<br>K2MST_mic_K01<br>K2MST_mic_K02 | C1 | Lec1-Lec15,<br>Lab1 | 1, 2, 3, 4 |

** - enter symbols for main-field-of-study/specialization educational effects

*** - from table above

Zał. nr 4 do ZW 64/2012

**FACULTY OF PURE AND APPLIED MATHEMATICS**
**SUBJECT CARD**

Name in Polish: **Analiza Funcjonalna i jej zastosowania**
Name in English: **Applied Functional_analysis**
**Main field of study (if applicable): APPLIED MATHEMATICS**
**Specialization (if applicable): Mathematics for Industry and Commerce**
**Level and form of studies: ~~1st/~~ 2nd* level, full-time / ~~part-time~~***
**Kind of subject: ~~obligatory~~ / optional / ~~university-wide~~***
**Subject code MAT0001573**
**Group of courses YES / ~~NO~~***

| | Lecture | Classes | Laboratory | Project | Seminar |
|---|---|---|---|---|---|
| Number of hours of organized classes in University (ZZU) | 30 | | 30 | | |
| Number of hours of total student workload (CNPS) | 150 | | | | |
| Form of crediting | Egamination | | | | |
| For group of courses mark (X) final course | X | | | | |
| Number of ECTS points | 5 | | | | |
| including number of ECTS points for practical (P) classes | 2 | | 2 | | |
| including number of ECTS points for direct teacher-student contact (BK) classes | 1,5 | | 1,5 | | |

**PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES**

1 Student knows and can apply basic concepts of mathematical analysis
2 Student knows and can apply basic concepts of linear algebra

**SUBJECT OBJECTIVES**

1 Study of the classical concepts of topology, elements of optimization and functional analysis and its application to solve simple inverse problems

*delete as applicable

**SUBJECT EDUCATIONAL EFFECTS**

relating to knowledge:

PEK_W01 knows the most important theorems and hypothesis of functional analysis, topology

PEK_W02 knows basic methods of optimisation

relating to skills:

PEK_U01 knows and can apply methods of functional analysis

relating to social competences:

PEK_K01 can, without assistance, search for necessary information in the literature, also in foreign languages

| **PROGRAMME CONTENT** | | |
|---|---|---|
| Form of classes - lecture | | Number of hours |
| Lec1 | Introduction to functional analysis – real world problems modeled by operator equations | 4 |
| Lec 2 | Elements of topology and linear spaces | 2 |
| Lec 3 | Linear normed spaces | 2 |
| Lec 4 | Hilbert spaces | 2 |
| Lec 5 | Linear operators | 4 |
| Lec 6 | Elements of spectra theory | 4 |
| Lec 7 | Fundaments of optimisation | 4 |
| Lec 8 | Role of functional analysis in solving inverse problems | 4 |
| Lec 9 | Elements of functional analysis in numerical methods | 4 |
| | Total hours | **30** |

| **Form of classes - laboratory** | | **Number of hours** |
|---|---|---|
| Lab1 | Solving of problems illustrating theory given in the lectures using mathematical packages for numerical computing | 30 |
| | Total hours | **30** |

| **TEACHING TOOLS USED** |
|---|
| N1. Lecture – traditional method |
| N2. Computer laboratory |
| N3. Consultations |
| N4. Student's self work – preparation for the laboratory |

**EVALUATION OF SUBJECT EDUCATIONAL EFFECTS ACHIEVEMENT**

| **Evaluation** (F – forming (during semester), P – concluding (at semester end) | Educational effect number | Way of evaluating educational effect achievement |
|---|---|---|
| F1 | PEK_W01<br>PEK_W02<br>PEK_K01 | examination |
| F2 | PEK_U01<br>PEK-K01 | oral presentations, tests, projects, raports |
| P=0.5*F1+0.5*F2 | | |

**PRIMARY AND SECONDARY LITERATURE**

**PRIMARY LITERATURE:**

E. Zeidler, Applied Functional Analysis, Springer-Verlag 1995
Ch.W. Groetsch, Inverse Problems in the Mathematical Science, Vieweg-Verlag 1993

**PRIMARY LITERATURE:**

L. Debnath, P. Mikusiński, Introduction to Hilbert Spaces with Applictions, Academic Press 2005

**SUBJECT SUPERVISOR (NAME AND SURNAME, E-MAIL ADDRESS)**

Prof. dr hab. Wojciech Okrasiński (Wojciech.Okrasinski@pwr.edu.pl)

MATRIX OF CORRELATION BETWEEN EDUCATIONAL EFFECTS FOR SUBJECT **APPLIED FUNCTIONAL ANALYSIS OPTIMIZATION MAT001573** AND EDUCATIONAL EFFECTS FOR MAIN FIELD OF STUDY **APPLIED MATHEMATICS** AND SPECIALIZATION **MATHEMATICS FOR INDUSTRY AND COMMERCE**

| **Subject educational effect** | **Correlation between subject educational effect and educational effects defined for main field of study and specialization (if applicable)**** | **Subject objectives***** | **Programme content***** | **Teaching tool number***** |
|---|---|---|---|---|
| **PEK_W01 (knowledge)** | K2MST_W03<br>K2MST_mic_W01 | C1 | Lec 1-Lec 9 | 1, 3 |
| **PEK_W02** | K2MST_W07<br>K2MST_mic_W02<br>K2MST_mic_W03 | C1 | Lec 1- Lec 9 | 1, 3 |
| **PEK_U01 (skills)** | K2MST_U24<br>K2MST_U25<br>K2MST_mic_U01<br>K2MST_mic_U02<br>K2MST_mic_U03 | C1 | Lab 1 | 2, 3, 4 |
| **PEK_K01 (competences)** | K2MST_K06<br>K2MST_mic_K01<br>K2MST_mic_K02 | C1 | Lec 1- Lec 9,<br>Lab 1 | 1, 2, 3, 4 |

** - enter symbols for main-field-of-study/specialization educational effects

*** - from table above

**FACULTY OF PURE AND APPLIED MATHEMATICS**

**SUBJECT CARD**

**Name in Polish METODY NIELINIOWE**
**Name in English NONLINEAR METHODS**
**Main field of study (if applicable): APPLIED MATHEMATICS**
**Specialization (if applicable): MATHEMATICS FOR INDUSTRY AND COMMERCE**
**Level and form of studies: ~~1st~~/ 2nd* level, full-time / ~~part-time*~~**
**Kind of subject: ~~obligatory~~ / optional / ~~university-wide*~~**
**Subject code MAT001574**
**Group of courses YES / ~~NO*~~**

| | Lecture | Classes | Laboratory | Project | Seminar |
|---|---|---|---|---|---|
| Number of hours of organized classes in University (ZZU) | 30 | | 30 | | |
| Number of hours of total student workload (CNPS) | 150 | | | | |
| Form of crediting | ~~Examination /~~ crediting with grade* | Examination / crediting with grade* | Examination / crediting with grade* | Examination / crediting with grade* | Examination / crediting with grade* |
| For group of courses mark (X) final course | X | | | | |
| Number of ECTS points | 5 | | | | |
| including number of ECTS points for practical (P) classes | 2 | | 2 | | |
| including number of ECTS points for direct teacher-student contact (BK) classes | 1,5 | | 1,5 | | |

*delete as applicable

**PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES**

1. Student has knowledge of concepts, theorems and methods of mathematical analysis
2. Student has knowledge of concepts and methods of differential equations

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**SUBJECT OBJECTIVES**

C1 Study basic concepts and nonlinear methods used in applications

**SUBJECT EDUCATIONAL EFFECTS**

relating to knowledge:

PEK_W01 has advanced knowledge concerning nonlinear methods

PEK_W02 knows numerical methods applied for approximate solving of mathematical problems in applied sciences

relating to skills:

PEK_U01 is able to construct mathematical models in advanced applications of mathematics

relating to social competences:

PEK_K01 can, without assistance, search for necessary information in the literature, also in

| | |
|---|---|
| foreign languages | |

**PROGRAMME CONTENT**

| **Form of classes - lecture** | | **Number of hours** |
|---|---|---|
| Lec 1 | Examples of nonlinear phenomena | 2 |
| Lec 2 | Examples of nonlinear phenomena | 2 |
| Lec 3 | Nonlinear oscillators | 2 |
| Lec 4 | Bifurcation and stability | 2 |
| Lec 5 | Van der Pol equation | 2 |
| Lec 6 | Duffig equation | 2 |
| Lec 7 | 2-D systems of nonlinear equations – equilibrium points | 2 |
| Lec 8 | Classification of the equilibrium points | 2 |
| Lec 9 | Systems of nonlinear equations - attractors | 2 |
| Lec 10 | Lorenc equation | 2 |
| Lec 11 | Strange attractors | 2 |
| Lec 12 | Belolusov-Zabotynski equation | 2 |
| Lec 13 | Benard cells – equations of hydrodynamics | 2 |
| Lec 14 | Examples of nonlinear optimisation | 2 |
| Lec 15 | Some methods of nonlinear optimisation | 2 |
| | Total hours | **30** |

| **Form of classes - laboratory** | | **Number of hours** |
|---|---|---|
| Lab 1 | Solving of problems illustrating theory given in the lectures by analytic methods and with MATLAB | 30 |
| | Total hours | **30** |

**TEACHING TOOLS USED**

N1. Lecture – traditional method
N2. Laboratory- solving problems with computers
N3. Consultations
N4. Student's self work – preparation for the laboratory

**EVALUATION OF SUBJECT EDUCATIONAL EFFECTS ACHIEVEMENT**

| **Evaluation** (F – forming (during semester), P – concluding (at semester end) | Educational effect number | Way of evaluating educational effect achievement |
|---|---|---|
| F1 | PEK_W01<br>PEK_W02 | test |
| F2 | PEK_U01<br>PEK_K01 | oral answers, calculus trainings, presentations, short tests, tests |
| P==0.5*F1+0.5*F2 | | |

**PRIMARY AND SECONDARY LITERATURE**

**PRIMARY LITERATURE:**

[1] D.W. Jordan, P. Smith, Nonlinear Ordinary Differential Equations
[2] G. Nicolis, Introduction to Nonlinear Science.

**SECONDARY LITERATURE:**

[1] D. P. Bertsekas, Nonlinear Programming

**SUBJECT SUPERVISOR (NAME AND SURNAME, E-MAIL ADDRESS)**

**Prof. dr hab. Wojciech Okrasiński** (Wojciech.Okrasinski@pwr.edu.pl)

MATRIX OF CORRELATION BETWEEN EDUCATIONAL EFFECTS FOR SUBJECT **NONLINEAR METHODS MAT001574** AND EDUCATIONAL EFFECTS FOR MAIN FIELD OF STUDY **APPLIED MATHEMATICS** AND SPECIALIZATION **MATHEMATICS FOR INDUSTRY AND COMMERCE**

| Subject educational effect | Correlation between subject educational effect and educational effects defined for main field of study and specialization (if applicable)** | Subject objectives*** | Programme content*** | Teaching tool number*** |
|---|---|---|---|---|
| **PEK_W01 (knowledge)** | K2MST_W04<br>K2MST_mic_W01 | C1 | Lec1-Lec15 | 1,3 |
| **PEK_W02** | K2MST_W10<br>K2MST_mic_W02<br>K2MST_mic_W03 | C1 | Lec1-Lec15 | 1,3 |
| **PEK_U01 (skills)** | K2MST_U15 K2MST_U24<br>K2MST_U25<br>K2MST_mic_U01<br>K2MST_mic_U02<br>K2MST_mic_U03 | C1 | Lab1 | 2,3,4 |
| **PEK_K01 (competences)** | K2MST_K06<br>K2MST_mic_K01<br>K2MST_mic_K02 | C1 | Lec1-Lec15<br>Lab1 | 1,2,3,4 |

** - enter symbols for main-field-of-study/specialization educational effects
*** - from table above

Zał. nr 4 do ZW 64/2012

**FACULTY OF PURE AND APPLIED MATHEMATICS**
**SUBJECT CARD**

**Name in Polish: Wprowadzenie do Problemów Odwrotnych**
**Name in English: Introduction to Inverse Problems**
**Main field of study (if applicable): APPLIED MATHEMATICS**
**Specialization (if applicable): MATHEMATICS FOR INDUSTRY AND COMMERCE, MODELLING, SIMULATION, OPTIMIZATION**
**Level and form of studies: ~~1st/~~ 2nd* level, full-time / ~~part-time~~***
**Kind of subject: ~~obligatory~~ / optional / ~~university-wide~~***
**Subject code MAT001575**
**Group of courses YES / ~~NO~~***

| | Lecture | Classes | Laboratory | Project | Seminar |
|---|---|---|---|---|---|
| Number of hours of organized classes in University (ZZU) | 30 | | 30 | | |
| Number of hours of total student workload (CNPS) | 150 | | | | |
| Form of crediting | ~~Examination~~ / crediting with grade* | Examination / crediting with grade* | Examination / crediting with grade* | Examination / crediting with grade* | Examination / crediting with grade* |
| For group of courses mark (X) final course | X | | | | |
| Number of ECTS points | 5 | | | | |
| including number of ECTS points for practical (P) classes | 2 | | 2 | | |
| including number of ECTS points for direct teacher-student contact (BK) classes | 1,5 | | 1,5 | | |

*delete as applicable

**PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES**

1 Student knows basic facts of mathematical analysis.
2 Knows MATLAB package for mathematical computing.

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**SUBJECT OBJECTIVES**

C1 Study of classical examples of inverse problems.
C2 Study of theory and basic concepts for inverse problems.
C3 Study of numerical methods for solving inverse, ill-posed problems.

**SUBJECT EDUCATIONAL EFFECTS**

relating to knowledge:
PEK_W01 knows the definition of well-posedness
PEK_W02 knows classical examples of inverse problems
PEK_W03 knows basic methods of regularization
PEK_W04 knows numerical methods for solving inverse problems

relating to skills:
PEK_U01 understand the definition of well-posedness
PEK_U02 be able to demonstrate examples of inverse problems
PEK_U03 be able to apply numerical methods to solve inverse problems

relating to social competences:
PEK_K01 can, without assistance, search for necessary information in the literature.
PEK_K02 understands the need for systematic work on course material

**PROGRAMME CONTENT**

| | **Form of classes - lecture** | **Number of hours** |
|---|---|---|
| Lec 1 | Introduction to inverse problems. Definition of the well-posedness. Important classes of inverse problems. | 2 |
| Lec 2 | Differentiation of a noisy data. | 2 |
| Lec 3 | Computerized tomography. The Radon transform. | 2 |
| Lec 4 | Inverse problems in image processing. | 2 |
| Lec 5 | Parameter identification problems. | 4 |
| Lec 6 | Ill-conditioned matrix equations | 2 |
| Lec 7 | Regularization of linear ill-posed problems. | 4 |
| Lec 8 | Tikhonov regularization. | 2 |
| Lec 9 | Maximum entropy regularization. | 2 |
| Lec 10 | Total variation regularization. | 2 |
| Lec 11 | Estimation of the regularization parameters. | 2 |
| Lec 12 | Iterative regularization | 4 |
| | Total hours | **30** |

| | **Form of classes - laboratory** | **Number of hours** |
|---|---|---|
| Lab 1 | Solving problems illustrating the methods given in the lecture using MATLAB package for scientific computing | 30 |
| | Total hours | **30** |

**TEACHING TOOLS USED**

N1. Lecture – traditional method
N2. Computer laboratory – working on a computer using MATLAB package for numerical computations
N3. Consultations
N4. Student's self work – preparation for the laboratory

**EVALUATION OF SUBJECT EDUCATIONAL EFFECTS ACHIEVEMENT**

| **Evaluation** (F – forming (during semester), P – concluding (at semester end) | Educational effect number | Way of evaluating educational effect achievement |
|---|---|---|
| F1 | PEK_W03, PEK_W04, PEK_U03,<br>PEK_K01, PEK_K02 | activity in the laboratory, oral presentation |
| F2 | PEK_W01, PEK_W02, PEK_W03, PEK_W04,<br>PEK_U01, PEK_U02, PEK_U03,<br>PEK_K01, PEK_K02, | test |
| P==0.5*F1+0.5*F2 | | |

**PRIMARY AND SECONDARY LITERATURE**

**PRIMARY LITERATURE:**


1 C. W. Groetsch. "Inverse Problems in the Mathematical Sciences". Vieweg, Braunschweig, 1993.
2 C. R. Vogel. „Computational Methods for Inverse Problems". SIAM, Philadelphia, PA, USA, 2002.


**SECONDARY LITERATURE:**


[1] H. W. Engl, M. Hanke, and A. Neubauer. "Regularization of Inverse Problems". Kluwer Academic Publishers, Dordrecht, 1996.
[2] A. A. Samarskii and P. N. Vabishchevich. "Numerical Methods for Solving Inverse Problems of Mathematical Physics". Walter de Gruyter, 2007.


**SUBJECT SUPERVISOR (NAME AND SURNAME, E-MAIL ADDRESS)**


Dr Monika Muszkieta (monika.muszkieta@pwr.edu.pl)

MATRIX OF CORRELATION BETWEEN EDUCATIONAL EFFECTS FOR SUBJECT **INTRODUCTION TO INVERSE PROBLEMS MAT001575** AND EDUCATIONAL EFFECTS FOR MAIN FIELD OF STUDY **APPLIED MATHEMATICS** AND SPECIALIZATION **MATHEMATICS FOR INDUSTRY AND COMMERCE MODELLING, SIMULATION, OPTIMIZATION**

| **Subject educational effect** | **Correlation between subject educational effect and educational effects defined for main field of study and specialization (if applicable)**lności (o ile dotyczy)** | **Subject objectives***** | **Programme content***** | **Teaching tool number***** |
|---|---|---|---|---|
| **PEK_W01 (knowledge)** | K2MST_W06<br>K2MST_W08,<br>K2MST_mic_W01<br>K2MST_mso_W01 | C1, C2, C3 | Lec 1, | 1 |
| **PEK_W02** | K2MST_W07<br>K2MST_W10<br>K2MST_mic_W02<br>K2MST_ mso _W02 | C1, C2, C3 | Lec 1 - Lec 6, Lab 1 | 1, 2, 3 |
| **PEK_W03** | K2MST_W13<br>K2MST_W12<br>K2MST_mic_W03<br>K2MST_ mso _W03 | C1, C2, C3 | Lec 7 – Lec 12, Lab 1 | 1, 2, 3 |
| **PEK_W04** | K2MST_W04 | C1, C2, C3 | Lec 2 - Lec 12, Lab 1 | 1, 2, 3, 4 |
| **PEK_U01 (skills)** | K2MST_U04,<br>K2MST_U05,<br>K2MST_U16,<br>K2MST_mic_U01<br>K2MST_ mso _U01 | C1, C2, C3 | Lec 1 | 1 |
| **PEK_U02** | K2MST_U06,<br>K2MST_U09<br>K2MST_U17<br>K2MST_mic_U02<br>K2MST_ mso _U02 | C1, C2, C3 | Lec 1 - Lec 6, Lab 1 | 1, 2, 3 |
| **PEK_U03** | K2MST_U24<br>K2MST_U25<br>K2MST_mic_U03<br>K2MST_ mso _U03 | C1, C2, C3 | Lec 7 – Lec 12, Lab 1 | 1, 2, 3 |
| **PEK_K01 (competences)** | K2MST_K05,<br>K2MST_K06<br>K2MST_mic_K01<br>K2MST_ mso _K01 | C1, C2, C3 | Lec 1- Lec 12, Lab 1 | 1, 2, 3, 4 |
| **PEK_K02** | K2MST_K03,<br>K2MST_K04<br>K2MST_mic_K02<br>K2MST_ mso _K02 | C1, C2, C3 | Lec 1- Lec 12, Lab 1 | 1, 2, 3, 4 |

** - enter symbols for main-field-of-study/specialization educational effects

*** - from table above

Zał. nr 4 do ZW 64/2012

**FACULTY OF PURE AND APPLIED MATHEMATICS**
**SUBJECT CARD**

**Name in Polish: Zagadnienia ze swobodnym brzegiem**
**Name in English: Free boundary problems**
**Main field of study (if applicable): APPLIED MATHEMATICS**
**Specialization (if applicable): Mathematics for Industry and Commerce**
**Level and form of studies: ~~1st/~~ 2nd* level, full-time / ~~part-time~~***
**Kind of subject: ~~obligatory~~/ optional / ~~university-wide~~***
**Subject code XXX**
**Group of courses YES / ~~NO~~***

| | Lecture | Classes | Laboratory | Project | Seminar |
|---|---|---|---|---|---|
| Number of hours of organized classes in University (ZZU) | 30 | 30 | | | |
| Number of hours of total student workload (CNPS) | 150 | | | | |
| Form of crediting | Crediting with grade | | | | |
| For group of courses mark (X) final course | X | | | | |
| Number of ECTS points | 5 | | | | |
| including number of ECTS points for practical (P) classes | 2 | 2 | | | |
| including number of ECTS points for direct teacher-student contact (BK) classes | 1,5 | 1,5 | | | |

*delete as applicable

**PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES**

1. Student has basic knowledge and abilities in the area of ordinary and partial differential equations.

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**SUBJECT OBJECTIVES**

C1 Study of mathematical models of phenomena in science and technology leading to free boundary problems.
C2 Study of basic analytical methods in examining free boundary problems.

**SUBJECT EDUCATIONAL EFFECTS**

relating to knowledge: student
PEK_W01 knows basic mathematical models connected with free boundary problems.
PEK_W02 knows basic analytical methods in examining free boundary problems.
relating to skills: student
PEK_U01 can build mathematical models leading to free boundary problems.
PEK_U02 can examine free boundary problems.
relating to social competences: student
PEK_K01 is able to take benefits form scientific literature
PEK_K02 knows limitations of his knowledge and understands the need of further education

| PROGRAMME CONTENT | | |
|---|---|---|
| **Form of classes - lecture** | | **Number of hours** |
| Lec 1 | Remaining basic theory of elliptic and parabolic partial differential equations. | 2 |
| Lec 2 | Stefan problem, notion of the free boundary. Inverse Stefan problem. | 2 |
| Lec 3 | Free boundary problems in melting and freezing. Modeling of problems connected with phase transition. | 4 |
| Lec 4 | Modeling of flows in porous media: Boussinesq equation, porous media equation. | 2 |
| Lec 5 | Self-similar solutions of porous media equation. | 2 |
| Lec 6 | Free boundary in solutions of porous media equation, finite speed of propagation of disturbances. Retention and penetration property. Large time behavior of solutions. | 2 |
| Lec 7 | Free boundary in reaction–diffusion–convection equations. | 4 |
| Lec 8 | Diffusion in solids. Free boundary problems. | 2 |
| Lec 9 | Modeling of flows in deformable media, spreading of impurities. | 4 |
| Lec 10 | Free boundary problems in digital image processing. | 2 |
| Lec 11 | Free boundary problems in financial mathematics. | 2 |
| Lec 12 | Stationary free boundary problems: dam problem, obstacle problems in calculus of variations. | 2 |
| | Total hours | 30 |

| **Form of classes - class** | | **Number of hours** |
|---|---|---|
| Cl 1 | Solving of problems illustrating theory given on lectures. | 30 |
| | Total hours | **30** |

| **TEACHING TOOLS USED** |
|---|
| N1. Lecture – traditional method.<br>N2. Classes – traditional method. |

**EVALUATION OF SUBJECT EDUCATIONAL EFFECTS ACHIEVEMENT**

| **Evaluation** (F – forming (during semester), P – concluding (at semester end) | Educational effect number | Way of evaluating educational effect achievement |
|---|---|---|
| F1 | PEK_W1, PEK_K1 | Final test |
| F2 | PEK_U1, PEK_U2, PEK_K1 | Oral presentations, tests. |
| P= 0.5*F1+0.5*F2 | | |

| **PRIMARY AND SECONDARY LITERATURE** |
|---|

**PRIMARY LITERATURE:**

R. M. Mattheij, S. W. Rienstra, J.H.M. ten Thije Boonkkamp, Partial Differential Equations, Modeling, Analysis, Computation, SIAM, Philadelphia 2005

J. Ockendon, S. Howison, A. Lacey & A. Movchan, Applied Partial Differential Equations, Oxford University Press, Oxford 1999.

A. Fasano, Parabolic Free Boundary Problems in Industrial and Biological Applications, SIMAI e-Lecture Notes, Volume 9, 2011

**SECONDARY LITERATURE:**

V. Alexiades, A.D. Solomon, Mathematical Modeling of Melting and Freezing Processes, Hemisphere – Taylor & Francis, Washington, DC, USA, 1983

J.L. Vazquez, The Porous Media Equation, Mathematical Theory, Clarendon Press, Oxford 2007

A.Friedman, Variational Principles and Free Boundary Problems, John Wiley and Sons, Inc

**SUBJECT SUPERVISOR (NAME AND SURNAME, E-MAIL ADDRESS)**

**Dr hab. Jan Goncerzewicz (**Jan.Goncerzewicz@pwr.edu.pl**)**

MATRIX OF CORRELATION BETWEEN EDUCATIONAL EFFECTS FOR SUBJECT **FREE BOUNDARY PROBLEMS MAT001576** AND EDUCATIONAL EFFECTS FOR MAIN FIELD OF STUDY **APPLIED MATHEMATICS** AND SPECIALIZATION **MATHEMATICS FOR INDUSTRY AND COMMERCE**

| Subject educational effect | Correlation between subject educational effect and educational effects defined for main field of study and specialization (if applicable)** | Subject objectives*** | Programme content*** | Teaching tool number*** |
|---|---|---|---|---|
| **PEK_W01 (knowledge)** | K2MST_W03<br>K2MST_mic_W01 | C1, C2 | Lec 1 - Lec 12 | F1 |
| **PEK_W02** | K2MST_W10<br>K2MST_mic_W02<br>K2MST_mic_W03 | C1, C2 | Lec 1 - Lec 12 | F1 |
| **PEK_U01 (skills)** | K2MST_U15<br>K2MST_U24<br>K2MST_U25 | C1, C2 | Cl 1 | F2 |
| **PEK_U02** | K2MST_U28<br>K2MST_U29<br>K2MST_U16 | C1, C2 | Cl 1 | F2 |
| **PEK_K01 (competences)** | K2MST_K06<br>K2MST_mic_K01 | C1, C2, | Lec 1 - Lec 12, Cl 1 | F2 |
| **PEK_K02** | K2MST_K01<br>K2MST_mic_K02 | C1-C2 | Wy1-Wy11, Ćw1 | 1, 2, 3, 4 |

** - enter symbols for main-field-of-study/specialization educational effects

*** - from table above

Zał. nr 4 do ZW 64/2012

**FACULTY OF PURE AND APPLIED MATHEMATICS**
**SUBJECT CARD**

**Name in Polish DYFUZJA NA SIECIACH ZŁOŻONYCH**
**Name in English DIFFUSION PROCESSES ON COMPLEX NETWORKS**
**Main field of study (if applicable): APPLIED MATHEMATICS**
**Specialization (if applicable): COMPUTATIONAL MATHEMATICS**
**Level and form of studies: ~~1st~~/ 2nd* level, full-time / ~~part-time*~~**
**Kind of subject: ~~obligatory /~~ optional ~~/ university-wide*~~**
**Subject code MAT001577**
**Group of courses YES / ~~NO~~***

| | Lecture | Classes | Laboratory | Project | Seminar |
|---|---|---|---|---|---|
| Number of hours of organized classes in University (ZZU) | 30 | | 30 | | |
| Number of hours of total student workload (CNPS) | 150 | | | | |
| Form of crediting | Crediting with grade | | | | |
| For group of courses mark (X) final course | | | | | |
| Number of ECTS points | 3 | | 3 | | |
| including number of ECTS points for practical (P) classes | 2 | | 2 | | |
| including number of ECTS points for direct teacher-student contact (BK) classes | 1,5 | | 1,5 | | |

*delete as applicable

**PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES**

Student has basic programming skills.

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**SUBJECT OBJECTIVES**

Mastering knowledge of computer simulation of diffusion processes on complex networks.

**SUBJECT EDUCATIONAL EFFECTS**

relating to knowledge:

PEK_W04 has in-depth knowledge in a subfield of theoretical or applied mathematics

PEK_W09 knows basic stochastic modelling methods in financial and actuarial mathematics or in science

relating to skills:

PEK_U18 can use stochastic processes as a tool for modelling complex phenomena and analysis of their evolution

relating to social competences:

K2MIC_K06 can, without assistance, search for necessary information in the literature, also in foreign languages

K2MIC_K02 can accurately formulate questions for deeper understanding of a given topic

| PROGRAMME CONTENT | | |
|---|---|---|
| **Form of classes - lecture** | | **Number of hours** |
| Lec 1 | Introduction to complex networks | 10 |
| Lec 2 | Diffusion and random walks | 2 |
| Lec 3 | Epidemic spreading in population networks | 6 |
| Lec 4 | Rumor and information spreading | 2 |
| Lec 5 | Opinion formation processes | 4 |
| Lec 6 | Diffusion of innovation | 6 |
| | Total hours | **30** |

| **Form of classes - laboratory** | | **Number of hours** |
|---|---|---|
| La 1 | Solving problems illustrating the content presented in the lectures | 30 |
| | Total hours | **30** |

**TEACHING TOOLS USED**

N1. Lecture – traditional method and presentations
N2. Problem and computing laboratory – using computer based methods
N3. Consultations
N4. Student's self work – preparation for the laboratory

**EVALUATION OF SUBJECT EDUCATIONAL EFFECTS ACHIEVEMENT**

| **Evaluation** (F – forming (during semester), P – concluding (at semester end) | Educational effect number | Way of evaluating educational effect achievement |
|---|---|---|
| F1 | PEK_W04<br>PEK_W09 | Mid-term exams |
| F2 | PEK_U18<br>PEK_K02<br>PEK_K06 | Oral presentations |
| C P==0.5*F1+0.5*F2 | | |

**PRIMARY AND SECONDARY LITERATURE**

**PRIMARY LITERATURE:**

Alain Barrat, Marc Barthelemy, Alessandro Vespignani, "Dynamical Processes on Complex Networks"

Romualdo Pastor-Satorras, Claudio Castellano, Piet Van Mieghem, Alessandro Vespignani, "Epidemic processes in complex networks", Revies of Modern Physics 87 (2015) 925-979

**SECONDARY LITERATURE:**

David Easley, Jon Kleinberg, „Networks, Crowds, and Markets: Reasoning about a Highly Connected World"

**SUBJECT SUPERVISOR (NAME AND SURNAME, E-MAIL ADDRESS)**

MATRIX OF CORRELATION BETWEEN EDUCATIONAL EFFECTS FOR SUBJECT **DIFFUSION PROCESSES ON COMPLEX NETWORKS MAT001577** AND EDUCATIONAL EFFECTS FOR MAIN FIELD OF STUDY **APPLIED MATHEMATICS AND SPECIALIZATION COMPUTATIONAL MATHEMATICS**

| Subject educational effect | Correlation between subject educational effect and educational effects defined for main field of study and specialization (if applicable)** | Subject objectives*** | Programme content*** | Teaching tool number*** |
|---|---|---|---|---|
| **PEK_W04 PEK_W09 (knowledge)** | K2MST_cm_W01 K2MST_cm _W02 K2MST_cm _W03 K2MST_W04, K2MST_W09 | C1 | Lec1-Lec6 | 1,3 |
| **PEK_U18 (skills)** | K2MST_U23 K2MST_U24 K2MST_U25 K2MST_cm _U01 K2MST_cm_U02 K2MST_cm_U03 | C1 | La1 | 2,3,4 |
| **PEK_K02 PEK_K06 (competences)** | K2MST_K02, K2MST_K06 K2MST_cm_K01 K2MST_cm_K02 | C1 | Lec1-Lec6, La1 | 1,2,3,4 |

** - enter symbols for main-field-of-study/specialization educational effects

*** - from table above

Zał. nr 4 do ZW 64/2012

**FACULTY OF PURE AND APPLIED MATHEMATICS**
**SUBJECT CARD**

**Name in Polish ANALIZA NIEUPORZĄDKOWANYCH ZBIORÓW DANYCH**
**Name in English ANALYSIS OF UNSTRUCTURED DATA**
**Main field of study (if applicable): APPLIED MATHEMATICS**
**Specialization (if applicable): COMPUTATIONAL MATHEMATICS**
**Level and form of studies: ~~1st~~/ 2nd* level, full-time / ~~part-time*~~**
**Kind of subject: ~~obligatory~~ / optional ~~/ university-wide*~~**
**Subject code MAT001578**
**Group of courses YES / ~~NO~~***

| | Lecture | Classes | Laboratory | Project | Seminar |
|---|---|---|---|---|---|
| Number of hours of organized classes in University (ZZU) | 30 | | | 30 | |
| Number of hours of total student workload (CNPS) | 150 | | | | |
| Form of crediting | crediting with grade | | | | |
| For group of courses mark (X) final course | X | | | | |
| Number of ECTS points | 5 | | | 3 | |
| including number of ECTS points for practical (P) classes | 2 | | | 2 | |
| including number of ECTS points for direct teacher-student contact (BK) classes | 1,5 | | | 1,5 | |

*delete as applicable

**PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES**

Student has basic programming skills.

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**SUBJECT OBJECTIVES**

Searching, extracting, storing ond computer-aided analysis of unstructered data (texts, blogs, web sites, social media posts etc.)

**SUBJECT EDUCATIONAL EFFECTS**

relating to knowledge:
PEK_W12 knows how to use Python and its scientific modules for data analysis

relating to skills:
PEK_U12 can perform an analysis of unstructured data by making use of Python and its modules

relating to social competences:
PEK_K06 can, without assistance, search for necessary information in the literature, also in foreign languages

PEK_K02 can accurately formulate questions for deeper understanding of a given topic

**PROGRAMME CONTENT**

| Form of classes - lecture | | Number of hours |
|---|---|---|
| Lec 1 | Data analysis in Python – PANDAS primer | 8 |
| Lec 2 | Retrieving and storing data | 6 |
| Lec 3 | Data visualisation | 2 |
| Lec 4 | Data wrangling | 2 |
| Lec 5 | Natural language processing with NLTK | 4 |
| Lec 6 | Sentiment analysis | 2 |
| Lec 7 | Document classification | 4 |
| Lec 8 | Handling big data | 2 |
| | Total hours | **30** |

| Form of classes - project | | Number of hours |
|---|---|---|
| Pr1 | Practical Preparation and presentations of projects illustrating methods given in the lectures. | 30 |
| | Total hours | **30** |

## TEACHING TOOLS USED

N1. Lecture – traditional method and presentations
N2. Student partial project presentation and final presentation
N3. Consultations
N4. Student's self work – work related to the project development

## EVALUATION OF SUBJECT EDUCATIONAL EFFECTS ACHIEVEMENT

| **Evaluation** (F – forming (during semester), P – concluding (at semester end) | Educational effect number | Way of evaluating educational effect achievement |
|---|---|---|
| F1 | PEK_W12<br>PEK_U12 | mid-term exams |
| F2 | PEK_U12<br>PEK_K06<br>PEK_K02 | Oral presentations |
| C P==0.5*F1+0.5*F2 | | |

## PRIMARY AND SECONDARY LITERATURE

**PRIMARY LITERATURE:**

S. Bird, E. Klein i E. Loper, „Natural Language Processing with Python”

I. H. Witten & E. Frank, „Data Mining. Practical Machine Learning Tools and Techniques”

W. McKinney, „Python for Data Analysis”

**SECONDARY LITERATURE:**

P. Giudici, „Applied Data Mining”

T. Segaran, „Programming Collective Intelligence”

I. Idris, „Python Data Analysis”

**SUBJECT SUPERVISOR (NAME AND SURNAME, E-MAIL ADDRESS)**

MATRIX OF CORRELATION BETWEEN EDUCATIONAL EFFECTS FOR SUBJECT **ANALYSIS OF UNSTRUCTURED DATA MAT001578** AND EDUCATIONAL EFFECTS FOR MAIN FIELD OF STUDY **APPLIED MATHEMATICS AND SPECIALIZATION COMPUTATIONAL MATHEMATICS**

| Subject educational effect | Correlation between subject educational effect and educational effects defined for main field of study and specialization (if applicable)** | Subject objectives*** | Programme content*** | Teaching tool number*** |
|---|---|---|---|---|
| **PEK_W12** | K2MST_W12<br>K2MST_cm_W01<br>K2MST_cm _W02<br>K2MST_cm _W03 | C1 | Lec1-Lec8 | 1,3 |
| **PEK_U12 (skills)** | K2MST_U21,<br>K2MST_U20<br>K2MST_U24<br>K2MST_U25<br>K2MST_cm _U01<br>K2MST_cm_U02<br>K2MST_cm_U03 | C1 | Pr1 | 2,3,4 |
| **PEK_K02**<br>**PEK_K06**<br>**(competences)** | K2MST_K02,<br>K2MST_K06<br>K2MST_cm_K01<br>K2MST_cm_K02 | C1 | Lec1-Le8,<br>Pr1 | 1,2,3,4 |

** - enter symbols for main-field-of-study/specialization educational effects

*** - from table above

Zał. nr 4 do ZW

**FACULTY OF PURE AND APPLIED MATHEMATICS**
**SUBJECT CARD**

**Name in Polish: PAKIETY STATYSTYCZNE**
**Name in English: Statistical Packages**
**Main field of study (if applicable): APPLIED MATHEMATICS**
**Specialization (if applicable): COMPUTATIONAL MATHEMATICS**
**Level and form of studies: ~~1st/~~ 2nd* level, full-time / ~~part-time~~***
**Kind of subject: ~~obligatory~~ / optional / ~~university-wide~~***
**Subject code MAT001579**
**Group of courses YES / ~~NO~~***

| | Lecture | Classes | Laboratory | Project | Seminar |
|---|---|---|---|---|---|
| Number of hours of organized classes in University (ZZU) | 30 | | 30 | | |
| Number of hours of total student workload (CNPS) | 150 | | | | |
| Form of crediting | ~~Examination~~ / crediting with grade* | Examination / crediting with grade* | Examination / crediting with grade* | Examination / crediting with grade* | Examination / crediting with grade* |
| For group of courses mark (X) final course | X | | | | |
| Number of ECTS points | 5 | | | | |
| including number of ECTS points for practical (P) classes | 2 | | 2 | | |
| including number of ECTS points for direct teacher-student contact (BK) classes | 1,5 | | 1,5 | | |

*delete as applicable

**PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES**

1. Student knows and can apply basic concepts of the probability theory
2. Student knows basic concepts of the mathematical statistics

**SUBJECT OBJECTIVES**

1Study of basic methods of data analysis.
2Acquisition of the ability to analyze data using statistical packages.
3Acquisition of the ability to write reports on statistical analyzes.
4Acquisition of skills in the English language sufficiently to enable the execution of statistical analyzes and write reports on these analyzes.

**SUBJECT EDUCATIONAL EFFECTS**

relating to knowledge:

PEK_W01 has statistical knowledge of the relationship between the variables in the databases

PEK_W02 knows English in the statistical analysis

PEK_W03 knows methods of using statistical packages for data analysis

relating to skills:

PEK_U01 can use a statistical package for data analysis

PEK_U02 can write a report on the statistical analysis in English

relating to social competences:

PEK_K01 can translate questions about the real phenomenon on the precise mathematical language

PEK_K02 can present the results of statistical analysis in a manner understandable to non-mathematicians

| **PROGRAMME CONTENT** | | |
|---|---|---|
| **Form of classes - lecture** | | **Number of hours** |
| Lec 1 | Descriptive statistics. Graphical representation of data. | 2 |
| Lec 2 | Comparison of two populations - Student test, nonparametric tests. | 2 |
| Lec 3 | Estimation of proportion. Chi-square goodness of fit test. | 2 |
| Lec 4 | Cross tabulation. Chi-squared test of independence. | 2 |
| Lec 5 | Simple linear regression - model, estimation, testing. | 2 |
| Lec 6 | Simple linear regression - prediction, checking assumptions, transformations. | 2 |
| Lec 7 | Test. | 2 |
| Lec 8 | Multiple linear regression - estimation, testing, checking assumptions. | 2 |
| Lec 9 | Multiple linear regression - analysis of variance, coefficient of determination. | 2 |
| Lec 10 | Multiple linear regression - the sum of the squares, generalized linear tests. | 2 |
| Lec 11 | Multiple linear regression - correlated predictors, the model selection criteria. | 2 |
| Lec 12 | Univariate analysis of variance - model, estimation of parameters, testing. | 2 |
| Lec 13 | Multivariate analysis of variance. | 2 |
| Lec 14 | Mixed models and generalized linear model. | 2 |
| Lec 15 | Test. | 2 |
| | Total hours | **30** |

| **Form of classes - laboratory** | | **Number of hours** |
|---|---|---|
| Lab 1 | Getting familiar with selected statistical package. | 2 |
| Lab 2 | Descriptive statistics and graphical representation of data. | 4 |

| | | |
|---|---|---|
| Lab 3 | The problem of two samples - Student tests, nonparametric tests, testing normality, graphical representation of data | 4 |
| Lab 4 | Tests and confidence intervals for the ratio - the proportion of a single ratio, chi-square goodness of fit test, chi-squared test of independence, graphical representation of data | 4 |
| Lab 5 | Simple linear regression - estimation, prediction, power, graphical representation of data and results | 4 |
| Lab 6 | Simple linear regression - diagnostics, transformations of variables | 4 |
| Lab 7 | Multiple linear regression - estimation, prediction, testing, diagnosis, selection of relevant variables. | 4 |
| Lab 8 | Analysis of variance - estimation, testing, comparison between groups, diagnostics | 4 |
| | Total hours | **30** |

| **TEACHING TOOLS USED** |
|---|
| N1. Lecture-computer presentation and traditional method.<br>N2. Computer laboratory - an independent analysis of the data, analysis reports.<br>N3. Consultations.<br>N4. Student's self work – preparation for the laboratory. |

**EVALUATION OF SUBJECT EDUCATIONAL EFFECTS ACHIEVEMENT**

| **Evaluation** (F – forming (during semester), P – concluding (at semester end) | Educational effect number | Way of evaluating educational effect achievement |
|---|---|---|
| F1 | PEK_U01<br>PEK_K01<br>PEK_K02 | written reports |
| F2 | PEK_W01<br>PEK_U01<br>PEK_K01<br>PEK_K02 | two tests |
| P=0,5 F1+0,5 F2 | | |

**PRIMARY AND SECONDARY LITERATURE**

**PRIMARY LITERATURE:**

D. S. Moore, G.P. McCabe, Introduction to the Practise of Statistics
M. H. Kutner, C. J. Nachstheim, J. Neter, W. Li, Applied Linear Statistical Models.

**SECONDARY LITERATURE:**

R. Freund, R. Littell, SAS System for Regression

**SUBJECT SUPERVISOR (NAME AND SURNAME, E-MAIL ADDRESS)**

**Dr hab. Małgorzata Bogdan** (Małgorzata.Bogdan@pwr.edu.pl)

MATRIX OF CORRELATION BETWEEN EDUCATIONAL EFFECTS FOR SUBJECT **STATISTICAL PACKAGES MAT001579** AND EDUCATIONAL EFFECTS FOR MAIN FIELD OF STUDY **APPLIED MATHEMATICS** AND SPECIALIZATION **COMPUTATIONAL MATHEMATICS**

| **Subject educational effect** | **Correlation between subject educational effect and educational effects defined for main field of study and specialization (if applicable)**** | **Subject objectives***** | **Programme content***** | **Teaching tool number***** |
|---|---|---|---|---|
| **PEK_W01 (wiedza)** | K2MST_W02<br>K2MST_W04<br>K2MST_W08<br>K2MST_W16<br>2MST_cm_W01 | C1 | Lec 1- Lec 15 | 1, 3 |
| **PEK_W02** | K2MST_W13<br>K2MST_cm _W02 | C4 | Lec 1- Lec 15,<br>Lab 1-Lab 8 | 1-4 |
| **PEK_W03** | K2MST_W12, K2MST_W18<br>K2MST_cm _W03 | C2 | Lec 1- Lec 15,<br>Lab 1-Lab 8 | 1-4 |
| **PEK_U01 (umiejętności)** | K2MST_U11<br>K2MST_U15<br>K2MST_U20<br>K2MST_U21<br>K2MST_cm _U01 | C2 | Lec 1- Lec 15,<br>Lab 1-Lab 8 | 1-4 |
| **PEK_U02** | K2MST_U24<br>K2MST_U25<br>K2MST_cm_U02<br>K2MST_cm_U03 | C3, C4 | Lab 1-Lab 8 | 2, 3, 4 |
| **PEK_K01 (kompetencje)** | K2MST_K02<br>K2MST_cm_K01 | C1, C2 | Lec 1- Lec 15,<br>Lab 1-Lab 8 | 1-4 |
| **PEK_K02** | K2MST_K05<br>K2MST_cm_K02 | C3, C4 | Lab 1-Lab 8 | 2, 3, 4 |

** - from table above

Zał. nr 4 do ZW

**FACULTY OF PURE AND APPLIED MATHEMATICS**
**SUBJECT CARD**

**Name in Polish: SYMULACJE KOMPUTEROWE PROCESÓW STOCHASTYCZNYCH**

**Name in English: Computer simulations of stochastic processes**

**Main field of study (if applicable): APPLIED MATHEMATICS**

**Specialization (if applicable): COMPUTATIONAL MATHEMATICS, MODELLING, SIMULATION, OPTIMIZATION**

**Level and form of studies: ~~1st/~~ 2nd* level, full-time / ~~part-time~~***

**Kind of subject: ~~obligatory~~ / optional / ~~university-wide~~***

**Subject code MAT001580**

**Group of courses YES / ~~NO~~***

| | Lecture | Classes | Laboratory | Project | Seminar |
|---|---|---|---|---|---|
| Number of hours of organized classes in University (ZZU) | 30 | | 30 | | |
| Number of hours of total student workload (CNPS) | 150 | | | | |
| Form of crediting | ~~Examination~~ / crediting with grade* | Examination / crediting with grade* | Examination / crediting with grade* | Examination / crediting with grade* | Examination / crediting with grade* |
| For group of courses mark (X) final course | X | | | | |
| Number of ECTS points | 5 | | | | |
| including number of ECTS points for practical (P) classes | 2 | | 2 | | |
| including number of ECTS points for direct teacher-student contact (BK) classes | 1,5 | | 1,5 | | |

**PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES**

Student knows and can apply basic concepts of the theory of stochastic processes.

**SUBJECT OBJECTIVES**

Mastering knowledge of computer simulations of stochastic processes with long memory property and heavy tails.

*delete as applicable

**SUBJECT EDUCATIONAL EFFECTS**

relating to knowledge:

PEK_W01 has in-depth knowledge of computer simulations of stochastic processes with long memory property and heavy tails.

PEK_W02 knows the basics of stochastic modeling in financial and actuarial mathematics or the natural sciences, especially physics, chemistry or biology

relating to skills:

PEK_U01 can construct algorithms with good numerical properties, used to solve common and unusual mathematical problems

relating to social competences:

PEK_K01 can, without assistance, search for necessary information in the literature, also in foreign languages

| **PROGRAMME CONTENT** | | |
|---|---|---|
| **Form of classes - lecture** | | **Number of hours** |
| Lec 1 | Generation of stable distributions and vectors | 6 |
| Lec 2 | Simulation of stable processes by integral and series representations | 6 |
| Lec 3 | Self-similar and stationary processes | 6 |
| Lec 4 | Generating processes with long memory | 6 |
| Lec 5 | Stable models with long memory in physics and economics | 6 |
| | Total hours | **30** |

| **Form of classes - laboratory** | | **Number of hours** |
|---|---|---|
| Lab 1 | Solving problems illustrating methods given in the lecture. | 30 |
| | Total hours | **30** |

**TEACHING TOOLS USED**

N1. Lecture-computer presentation and traditional method.
N2. Computer Laboratory with Matlab
N3. Consultations.
N4. Student's self work – preparation for the laboratory.

**EVALUATION OF SUBJECT EDUCATIONAL EFFECTS ACHIEVEMENT**

| **Evaluation** (F – forming (during semester), P – concluding (at semester end) | Educational effect number | Way of evaluating educational effect achievement |
|---|---|---|
| F1 | PEK_W01<br>PEK_W02<br>PEK_K01 | test |

| | | |
|---|---|---|
| F2 | PEK_U01<br>PEK_K01 | written reports |
| P=0.5*F1+0.5*F2 | | |

| PRIMARY AND SECONDARY LITERATURE |
|---|
| **PRIMARY LITERATURE:**<br>P. Doukhan, G. Oppenheim, M.S. Taqqu, Theory and Applications of Long-range Dependence, Birkhauser, Boston, 2004.<br>A. Janicki, A Weron, Simulation and Chaotic Behavior of Stable Stochastic Processes, Marcel Dekker, New York, 1994.<br>G. Samorodnitsky, M.S. Taqqu, Stable Non-Gaussian Random Processes, Chapman & Hall, New York, 1994.<br>**SECONDARY LITERATURE:**<br>J. Beran, Statistics for Long-memory Processes, Chapman & Hall, New York, 1994.<br>P. Cizek, W. Haerdle, R. Weron (red.), Statistical tools for finance and insurance, Springer, Berlin, 2011 |
| **SUBJECT SUPERVISOR (NAME AND SURNAME, E-MAIL ADDRESS)** |
| **Dr Krzysztof Burnecki** (Krzysztof.Burnecki@pwr.edu.pl)<br>**Dr hab. Marcin Magdziarz** (Marcin.Magdziarz@pwr.edu.pl) |

MATRIX OF CORRELATION BETWEEN EDUCATIONAL EFFECTS FOR SUBJECT

# COMPUTER SIMULATIONS OF STOCHASTIC PROCESSES

**MAT001580** AND EDUCATIONAL EFFECTS FOR MAIN FIELD OF STUDY **APPLIED MATHEMATICS** AND SPECIALIZATION **COMPUTATIONAL MATHEMATICS, MODELLING, SIMULATION, OPTIMIZATION**

| **Subject educational effect** | **Correlation between subject educational effect and educational effects defined for main field of study and specialization (if applicable)**** | **Subject objectives***** | **Programme content***** | **Teaching tool number***** |
|---|---|---|---|---|
| **PEK_W01** **(wiedza)** | K2MST_W04<br>K2MST_W05<br>K2MST_cm_W01<br>K2MST_mso_W01<br>K2MST_mso_W02<br>K2MST_mso_W03 | C1 | Lec 1-Lec 5 | 1, 3 |
| **PEK_W02** | K2MST_W09<br>K2MST_cm_W02<br>K2MST_cm_W03 | C1 | Lec 1-Lec 5 | 1, 3 |
| **PEK_U01** **(umiejętności)** | K2MST_U13<br>K2MST_U17<br>K2MST_U23<br>K2MST_U24<br>K2MST_U25<br>K2MST_U30<br>K2MST_cm_U01<br>K2MST_cm_U02<br>K2MST_cm_U03<br>K2MST_mso_U01<br>K2MST_mso_U02<br>K2MST_mso_U03 | C1 | Lab 1 | 2, 3, 4 |
| **PEK_K01** **(kompetencje)** | K2MST_K03<br>K2MST_K06<br>K2MST_cm_K01<br>K2MST_cm_K02<br>K2MST_mso_K01<br>K2MST_mso_K02 | C1 | Lec 1-Lec 5, Lab 1 | 1, 2, 3, 4 |

** - from table above

Zał. nr 4 do ZW 64/2012

**FACULTY OF FUNDAMENTAL PROBLEMS OF TECHNOLOGY**
**SUBJECT CARD**

**Name in Polish Teoria estymacji**
**Name in English: Estimation theory**
**Main field of study (if applicable): APPLIED MATHEMATICS**
**Specialization (if applicable): COMPUTATIONAL MATHEMATICS**
**Level and form of studies: ~~1st/~~ 2nd* level, full-time / ~~part-time~~***
**Kind of subject: ~~obligatory~~ / optional / ~~university-wide~~***
**Subject code MAT001581**
**Group of courses YES / ~~NO~~***

| | Lecture | Classes | Laboratory | Project | Seminar |
|---|---|---|---|---|---|
| Number of hours of organized classes in University (ZZU) | 30 | | 30 | | |
| Number of hours of total student workload (CNPS) | 150 | | | | |
| Form of crediting | ~~Examination~~ / crediting with grade* | Examination / crediting with grade* | Examination / crediting with grade* | Examination / crediting with grade* | Examination / crediting with grade* |
| For group of courses mark (X) final course | X | | | | |
| Number of ECTS points | 5 | | | | |
| including number of ECTS points for practical (P) classes | 2 | | 2 | | |
| including number of ECTS points for direct teacher-student contact (BK) classes | 1,5 | | 1,5 | | |

*delete as applicable

**PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES**

1Student knows how to use statistical packages
2Student has a basic knowledge of mathematical statistics.
3Student has a basic knowledge of mathematical analysis and functional analysis
4Student has basic programming skills.

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**SUBJECT OBJECTIVES**

1Learning of statistical criteria for assessing the quality of statistical estimation
2Learning basic parametric estimation methods and their properties.
3Learning basic non-parametric estimation methods and their properties.
4Ability to program advanced statistical methods.
5Ability to carry out simulation studies.
6Ability to evaluate properties of statistical methods based on simulation studies.
7Mastering of English vocabulary in the field of estimation methods .
8Report writing skills in English.

**SUBJECT EDUCATIONAL EFFECTS**

relating to knowledge:

PEK_W01 knows the basic parametric estimation methods.
PEK_W02 knows the basic non-parametric estimation methods.
PEK_W03 knows the basic criteria for assessing the quality of the estimation.
PEK_W04 knows the theoretical basis of statistical simulation.
PEK_W05 knows English in the extent necessary for the creation of simulation reports.
PEK_W06 knows Programming Languages enable to carry out the simulation study.

relating to skills:

PEK_U01 able to apply advanced statistical methods to analyze real data.
PEK_U02 can use programming languages to program the high-order complex statistical methods and simulation tests and to carry out simulation studies.
PEK_U03 able to assess the properties of statistical methods based on simulation studies.
PEK_U04 can develop a report in English summarizing the results of simulation studies.

relating to social competences:

PEK_K01 can benefit from the scientific literature in English, including reaching the source materials and review them.
PEK_K02 understands the need for systematic work to improve knowledge

**PROGRAMME CONTENT**

| **Form of classes - lecture** | | **Number of hours** |
|---|---|---|
| Lec 1 | Basic concepts of estimation theory: bias, variance, mean square error matrix of Fisher information, efficiency, asymptotic normality | 2 |
| Lec 2 | Theoretical basis of simulation methods and replication | 2 |
| Lec 3 | Bias and variance estimation - bootstrap, Jacknife, the delta method | 2 |
| Lec 4 | Construction of confidence intervals - classic and boostrap intervals | 2 |
| Lec 5 | Nonparametric density estimation - histogram and its properties | 2 |
| Lec 6 | Nonparametric density estimation - kernel estimator and its properties | 2 |
| Lec 7 | Selection of bandwidth in the kernel estimator | 2 |
| Lec 8 | Modifications of kernel estimator - variable bandwidth, higher-order kernels | 2 |
| Lec 9 | Estimation of density through orthogonal expansions | 2 |
| Lec 10 | Estimation of density - local likelihood function and maximum likelihood method with smoothing | 2 |
| Lec 11 | Nonparametric regression function estimation - estimation of kernel | 2 |

| | | |
|---|---|---|
| Lec 12 | Selection of the bandwidth and modification of the kernel estimator of regression function. | 2 |
| Lec 13 | Hazard function estimation - parametric and non-parametric methods. | 2 |
| Lec 14 | Empirical Bayesian methods - Stein estimator | 2 |
| Lec 15 | Test | 2 |
| | Total hours | 30 |

| **Form of classes – laboratory** | | **Number of hours** |
|---|---|---|
| Lab 1 | Parametric estimation - method of maximum likelihood. Bias, variance, mean square error - estimation using computer simulations. | 4 |
| Lab 2 | Estimation of bias, variance and construction of confidence intervals using the method of substitution and replication methods (bootstrap, jackknife). Estimating the quality of estimators based on simulation studies. | 4 |
| Lab 3 | Estimating the several parameters - asymptotic covariance matrix, the covariance matrix estimation using the method of substitution and replication methods. Estimating the quality of estimators based on simulation studies. | 4 |
| Lab 4 | Nonparametric estimation of density - the histogram, method of the nearest neighbor, kernel estimator, orthogonal expansions. Smoothing parameter selection. Quality rating based on simulation studies. | 6 |
| Lab 5 | Nonparametric estimation of the regression function. Estimators: kernel, local polynomial, the nearest neighbor, the smooth spline functions. Construction of confidence intervals and bands using the bootstrap method. Smoothing parameter selection. Quality rating based on simulation studies. | 6 |
| Lab 6 | Estimation of survival function and hazard function with parametric and nonparametric methods. Construction of confidence intervals through approximation with the normal distribution and the bootstrap method. Quality rating based on simulation studies. | 4 |
| Lab 7 | Empirical Bayesian methods. Quality assessment using simulation studies. | 4 |
| | Total hours | 30 |

**TEACHING TOOLS USED**

N1. Lecture problem - computer presentation and traditional method
N2. Laboratory - self development of programs for simulation, reports from analyses
N3. Consultations
N4. Student’s self work – preparation for the laboratory

**EVALUATION OF SUBJECT EDUCATIONAL EFFECTS ACHIEVEMENT**

| **Evaluation** (F – forming (during semester), P – concluding (at semester end) | Educational effect number | Way of evaluating educational effect achievement |
|---|---|---|
| F1 | All subject effects of the course | Reports and activity during the laboratory. |
| F2 | PEK_W01<br>PEK_W02<br>PEK_W03<br>PEK_W04<br>PEK_W05 | Test |
| P=0,75*F1+0,25*F2 | | |

**PRIMARY AND SECONDARY LITERATURE**

**PRIMARY LITERATURE:**


[1] L. Devroye, A Course in Density Estimation
[2] B. Efron, R. Tibshirani, Introduction to the Bootstrap
[3] B. Silverman, Density Estimation for Statistics and Data Analysis.
[4] W. Härdle, Smoothing Techniques with implementation in S
[5] A.W.Bowman and A. Azzalini, Applied Smoothing Techniques for Data Analysis, The kernel approach with S-Plus Illustrations
[6] P.J. Green and B.W.Silverman, Nonparametric regression and Generalized Linear Models


**SUBJECT SUPERVISOR (NAME AND SURNAME, E-MAIL ADDRESS)**


**Dr hab. Małgorzata Bogdan** (Malgorzata.Bogdan@pwr.edu.pl)

MATRIX OF CORRELATION BETWEEN EDUCATIONAL EFFECTS FOR SUBJECT **ESTIMATION THEORY MAT001581** AND EDUCATIONAL EFFECTS FOR MAIN FIELD OF STUDY **APPLIED MATHEMATICS** AND SPECIALIZATION **COMPUTATIONAL MATHEMATICS**

| Subject educational effect | Correlation between subject educational effect and educational effects defined for main field of study and specialization (if applicable)** | Subject objectives*** | Programme content*** | Teaching tool number*** |
|---|---|---|---|---|
| **PEK_W01 (knowledge)** | K2MST_W04<br>K2MST_cm_W01 | C2 | Lec 1-Lec 4, Lec 13, Lec 14<br>Lab 1-Lab 3, Lab 6, Lab 7 | 1-4 |
| **PEK_W02** | K2MST_W15<br>K2MST_cm _W02 | C3 | Lec 5-Lec 4,<br>Lab 4-Lab 7 | 1-4 |
| **PEK_W03** | K2MST_W16<br>K2MST_cm _W03 | C1 | Lec 1-Lec 14,<br>Lab 1-Lab 7 | 1-4 |
| **PEK_W04** | K2MST_W18 | C5,C6 | Lec 2-Lec 14,<br>Lab 1-Lab 7 | 1-4 |
| **PEK_W05** | K2MST_W13 | C7, C8 | Lec 1-Lec 14,<br>Lab 1-Lab 7 | 1-4 |
| **PEK_W06** | K2MST_W12 | C4, C5, C6 | Lec 2-Lec 14,<br>Lab 1-Lab 7 | 1-4 |
| **PEK_U01 (skills)** | K2MST_U11,<br>K2MST_U24<br>K2MST_cm _U01 | C1-C4 | Lec 1-Lec 14,<br>Lab 1-Lab 7 | 1-4 |
| **PEK_U02** | K2MST_U12<br>K2MST_U02,<br>K2MST_cm_U02 | C4-C6 | Lab 1-Lab 7 | 2, 3, 4 |
| **PEK_U03** | K2MST_U20,<br>K2MST_U25<br>K2MST_cm_U03 | C5-C6 | Lec 2, Lab 1-Lab 7 | 1-4 |
| **PEK_U04** | K2MST_U21 | C7-C8 | Lab 1-Lab 7 | 2, 3, 4 |
| **PEK_K01 (competences)** | K2MST_K06<br>K2MST_cm_K01 | C4-C8 | Lab 1-Lab 7 | 2, 3, 4 |
| **PEK_K02** | K2MST_K01<br>K2MST_cm_K02 | C1-C8 | Lec 1-Lec 14,<br>Lab 1-Lab 7 | 1-4 |

** - enter symbols for main-field-of-study/specialization educational effects

*** - from table above

Zał. nr 4 do ZW 64/2012

**FACULTY OF PURE AND APPLIED MATHEMATICS**
**SUBJECT CARD**

**Name in Polish: Matematyczne przetwarzanie obrazów**
**Name in English: Mathematical Image Processing**
**Main field of study (if applicable): APPLIED MATHEMATICS**
**Specialization (if applicable): MODELLING, SIMULATION, OPTIMIZATION**
**Level and form of studies: ~~1st/~~ 2nd* level, full-time / ~~part-time~~***
**Kind of subject: ~~obligatory~~ / optional / ~~university-wide~~***
**Subject code MAT001582**
**Group of courses YES / ~~NO~~***

| | Lecture | Classes | Laboratory | Project | Seminar |
|---|---|---|---|---|---|
| Number of hours of organized classes in University (ZZU) | 30 | | 30 | | |
| Number of hours of total student workload (CNPS) | 150 | | | | |
| Form of crediting | ~~Examination~~ / crediting with grade* | Examination / crediting with grade* | Examination / crediting with grade* | Examination / crediting with grade* | Examination / crediting with grade* |
| For group of courses mark (X) final course | X | | | | |
| Number of ECTS points | 5 | | | | |
| including number of ECTS points for practical (P) classes | 2 | | 2 | | |
| including number of ECTS points for direct teacher-student contact (BK) classes | 1,5 | | 1,5 | | |

*delete as applicable

**PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES**

Knows basic concepts of theory of partial differential equations
Knows MATLAB package for mathematical computing

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**SUBJECT OBJECTIVES**

C1 Study of mathematical models in image processing.
C2 Study of numerical methods for solving problems in image processing.
C3 Application of acquired knowledge to construction and analysis of mathematical models in image processing

**SUBJECT EDUCATIONAL EFFECTS**

relating to knowledge:
PEK_W01 knows basic models for image restoration
PEK_W02 knows basic variational models for image segmentation
PEK_W03 knows numerical methods for solving problems in image processing

relating to skills:
PEK_U01 be able to demonstrate the difference between known models of image restoration
PEK_U02 be able to demonstrate the difference between known models of image segmentation
PEK_U03 be able to apply numerical methods to solve mathematical problems in image processing

relating to social competences:
PEK_K01 can, without assistance, search for necessary information in the literature.
PEK_K02 understands the need for systematic work on course material

**PROGRAMME CONTENT**

| **Form of classes - lecture** | | **Number of hours** |
|---|---|---|
| Lec 1 | Overview of fundamental problems in image processing. Representation of images. Models of image degradation. | 2 |
| Lec 2 | Linear diffusion filter. Gaussian smoothing in the frequency domain. | 2 |
| Lec 3 | Nonlinear diffusion filters. Isotropic and anisotropic diffusion models. | 4 |
| Lec 4 | Discretization of the nonlinear diffusion filter. | 2 |
| Lec 5 | Introduction to variational models for image restoration. | 2 |
| Lec 6 | Image denoising by total variation regularization. | 2 |
| Lec 7 | First order numerical schemes for total variation minimization. | 4 |
| Lec 8 | Image deblurring model. | 2 |
| Lec 9 | Total variation model for image inpainting. | 2 |
| Lec 10 | The Mumford-Shah model for image segmentation and its approximations. | 4 |
| Lec 11 | Active contours model for image segmentation. | 4 |
| | Total hours | **30** |

| **Form of classes - laboratory** | | **Number of hours** |
|---|---|---|
| Lab 1 | Basic operation on images. Degradation of images. Gaussian smoothing. | 4 |
| Lab 2 | Solving selected problems illustrating theory given in the lectures using mathematical MATLAB package for numerical computing | 26 |
| | Total hours | **30** |

| TEACHING TOOLS USED |
|---|
| N1. Lecture – traditional method supported by multimedial presentation<br>N2. Computer laboratory – working on a computer using MATLAB package for numerical computations<br>N3. Consultations<br>N4. Student's self work – work on the project |

**EVALUATION OF SUBJECT EDUCATIONAL EFFECTS ACHIEVEMENT**

| **Evaluation** (F – forming (during semester), P – concluding (at semester end) | Educational effect number | Way of evaluating educational effect achievement |
|---|---|---|
| F1 | PEK_W01, PEK_W02, PEK_W03,<br>PEK_U01, PEK_U02, PEK_U03,<br>PEK_K01, PEK_K02, | activity in the laboratory |
| F2 | PEK_W01, PEK_W02, PEK_W03,<br>PEK_U01, PEK_U02, PEK_U03,<br>PEK_K01, PEK_K02, | oral presentation, report |
| P==0.2*F1+0.8*F2 | | |

| PRIMARY AND SECONDARY LITERATURE |
|---|
| **PRIMARY LITERATURE:**<br>G. Aubert and P. Kornprobst „Mathematical Problems in Image Processing: Partial Differential Equations and the Calculus of Variations", Springer-Verlag, 2007.<br>T. Chan and J. Shen „Image Processing and Analysis: Variational, PDE, Wavelet, and Stochastic Methods", SIAM, 2006.<br><br>**SECONDARY LITERATURE:**<br>Scherzer (Editor) „Handbook of Mathematical Methods in Imaging", Springer-Verlag, 2010. |
| **SUBJECT SUPERVISOR (NAME AND SURNAME, E-MAIL ADDRESS)** |
| Dr Monika Muszkieta (monika.muszkieta@pwr.edu.pl) |

MATRIX OF CORRELATION BETWEEN EDUCATIONAL EFFECTS FOR SUBJECT **MATHEMATICAL IMAGE PROCESSING MAP001582** AND EDUCATIONAL EFFECTS FOR MAIN FIELD OF STUDY **APPLIED MATHEMATICS** AND SPECIALIZATION **MODELLING, SIMULATION, OPTIMIZATION**

| **Subject educational effect** | **Correlation between subject educational effect and educational effects defined for main field of study and specialization (if applicable)**** | **Subject objectives***** | **Programme content***** | **Teaching tool number***** |
|---|---|---|---|---|
| **PEK_W01 (knowledge)** | K2MST_W04, K2MST_mso_W01 | C1, C2, C3 | Lec 1, Lec 2, Lec 3, Lec 5, Lec 6, Lec 8, Lec 9 Lab 1, Lab 2 | 1, 2, 3, 4 |
| **PEK_W02** | K2MST_W06, K2MST_mso_W02 | C1, C2, C3 | Lec 10, Lec 11 Lab 1, Lab 2 | 1, 2, 3, 4 |
| **PEK_W03** | K2MST_W07 K2MST_W13 K2MST_mso_W03 | C1, C2, C3 | Lec 4, Lec 7 Lab 1, Lab 2 | 1, 2, 3, 4 |
| **PEK_U01 (skills)** | K2MST_U04 K2MST_U05, K2MST_U06, K2MST_mso_U01 | C1, C2, C3 | Lec 1, Lec 2, Lec 3, Lec 5, Lec 6, Lec 8, Lec 9 Lab 1, Lab 2 | 1, 2, 3, 4 |
| **PEK_U02** | K2MST_U09 K2MST_U16 K2MST_mso_U01 | C1, C2, C3 | Lec 10, Lec 11 Lab 1, Lab 2 | 1, 2, 3, 4 |
| **PEK_U03** | K2MST_U17 K2MST_U24 K2MST_U25 K2MST_mso_U03 | C1, C2, C3 | Lec 4, Lec 7 Lab 1, Lab 2 | 1, 2, 3, 4 |
| **PEK_K01 (competences)** | K2MST_K05 K2MST_K06 K2MST_mso_K01 | C1, C2, C3 | Lec 1- Lec 11, Lab 1, Lab 2 | 1, 2, 3, 4 |
| **PEK_K02** | K2MST_K03 K2MST_K04 K2MST_mso_K02 | C1, C2, C3 | Lec 1- Lec 11, Lab 1, Lab 2 | 1, 2, 3, 4 |

** - enter symbols for main-field-of-study/specialization educational effects

*** - from table above

**FACULTY OF PURE AND APPLIED MATHEMATICS**
**SUBJECT CARD**

**Name in Polish: TEORIA KOLEJEK I SIECI KOMUNIKACYJNE**
**Name in English: Queues and Communication Networks**
**Main field of study (if applicable): APPLIED MATHEMATICS**
**Specialization (if applicable): MODELLING, SIMULATION, OPTIMIZATION**
**Level and form of studies: ~~1st~~/ 2nd* level, full-time ~~/ part-time~~***
**Kind of subject: ~~obligatory~~ / optional / ~~university-wide~~***
**Subject code MAT001583**
**Group of courses YES /~~NO~~***

| | Lecture | Classes | Laboratory | Project | Seminar |
|---|---|---|---|---|---|
| Number of hours of organized classes in University (ZZU) | 30 | 30 | | | |
| Number of hours of total student workload (CNPS) | 150 | | | | |
| Form of crediting | Examination / ~~crediting with grade~~* | Examination / crediting with grade* | Examination / crediting with grade* | Examination / crediting with grade* | Examination / crediting with grade* |
| For group of courses mark (X) final course | X | | | | |
| Number of ECTS points | 5 | | | | |
| including number of ECTS points for practical (P) classes | 2 | 2 | | | |
| including number of ECTS points for direct teacher-student contact (BK) classes | 1,5 | 1,5 | | | |

*delete as applicable

**PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES**

1. Student has an elementary knowledge of probability theory.

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**SUBJECT OBJECTIVES**

C1 Learning and mastery of key concepts and methods in the field of queueing theory and communication networks

**SUBJECT EDUCATIONAL EFFECTS**

relating to knowledge:
PEK_W01 knows the most important theorems and hypotheses of queuing theory
PEK_W02 knows the basics of stochastic modeling of stochastic networks with applications to biology, physics, economics etc.
relating to skills:
PEK_U01 can construct queuing models used in various applications
relating to social competences:
PEK_K01 can by himself/herself search for information in the literature, even in foreign languages

| PROGRAMME CONTENT | | |
|---|---|---|
| **Form of classes - lecture** | | **Number of hours** |
| Lec 1 | Basic concepts from Markov processes theory | 2 |
| Lec 2 | An outline of the theory of point processes | 2 |
| Lec 3 | Steady state analysis of Markovian queues | 4 |
| Lec 4 | Erlang Loss System | 2 |
| Lec 5 | Open Jackson network and Gordon-Newel network | 6 |
| Lec 6 | Multi-class Queue | 4 |
| Lec 7 | Multiserver queus and various queue disciplines | 4 |
| Lec 8 | Queues with feedback and loss systems | 4 |
| Lec 9 | Transient analysis of Markovian queues | 2 |
| | Total hours | 30 |

| **Form of classes - class** | | **Number of hours** |
|---|---|---|
| Cl 1 | Illustration of all models.. Analytical and computer methods. Examples of queuing models. | 30 |
| | Total hours | 30 |

| TEACHING TOOLS USED |
|---|
| N1. Lecture problem - traditional method.<br>N2. Problem and counting exercises.<br>N3. Consultations.<br>N4. Student's self work - preparation for exercises. |

**EVALUATION OF SUBJECT EDUCATIONAL EFFECTS ACHIEVEMENT**

| **Evaluation** (F – forming (during semester), P – concluding (at semester end) | Educational effect number | Way of evaluating educational effect achievement |
|---|---|---|
| F1 | PEK_W01<br>PEK_W02<br>PEK_K01 | exam |
| F2 | PEK_U01<br>PEK_K01 | oral responses, tests, small tests |
| P=0.5*F1+0.5*F2 | | |

| PRIMARY AND SECONDARY LITERATURE |
|---|

**PRIMARY LITERATURE:**

[1] Asmussen, S. (2003) Applied Probability and Queues, Springer.

**SECONDARY LITERATURE:**

1 Cohen, J.W. (1969) The Single Server Queue North, Holland.
2 Takacs, L. (1962) Introduction to the Theory of Queues Oxford University Press.

**SUBJECT SUPERVISOR (NAME AND SURNAME, E-MAIL ADDRESS)**

**Prof. dr hab. Zbigniew Palmowski** (Zbigniew.Palmowski@pwr.edu.pl)

MATRIX OF CORRELATION BETWEEN EDUCATIONAL EFFECTS FOR SUBJECT **QUEUES AND COMMUNICATION NETWORKS MAT001583** AND EDUCATIONAL EFFECTS FOR MAIN FIELD OF STUDY **APPLIED MATHEMATICS** AND SPECIALIZATION **MODELLING, SIMULATION, OPTIMIZATION**

| Subject educational effect | Correlation between subject educational effect and educational effects defined for main field of study and specialization (if applicable)** | Subject objectives*** | Programme content*** | Teaching tool number*** |
|---|---|---|---|---|
| **PEK_W01 (knowledge)** | K2MST_W03<br>K2MST_mso_W01 | C1 | Lec 1-Lec 10 | 1, 3 |
| **PEK_W02** | K2MST_W09<br>K2MST_mso_W02<br>K2MST_mso_W03 | C1 | Lec 1-Lec 10 | 1, 3 |
| **PEK_U01 (skills)** | K2MST_U15<br>K2MST_U24<br>K2MST_U25<br>K2MST_mso_U01<br>K2MST_mso_U02<br>K2MST_mso_U03 | C1 | Cl 1 | 2, 3, 4 |
| **PEK_K01 (competences)** | K2MST_K06<br>K2MST_mso_K01<br>K2MST_mso_K02 | C1 | Lec 1-Lec 10,<br>Cl 1 | 1, 2, 3, 4 |

** - enter symbols for main-field-of-study/specialization educational effects

*** - from table above

Zał. nr 4 do ZW

**FACULTY OF PURE AND APPLIED MATHEMATICS**
**SUBJECT CARD**

Name in Polish: **Zaawansowane zagadnienia z teorii gier dynamicznych**
**Name in English: Advanced Topics in Dynamic Games**
**Main field of study (if applicable): Applied Mathematics**
**Specialization (if applicable): Modelling, Simulation, Optimization**
**Level and form of studies: ~~1st/~~ 2nd* level, full-time / ~~part-time~~***
**Kind of subject: ~~obligatory /~~ optional ~~/ university-wide~~***
**Subject code MAT001584**
**Group of courses YES / ~~NO~~***

| | Lecture | Classes | Laboratory | Project | Seminar |
|---|---|---|---|---|---|
| Number of hours of organized classes in University (ZZU) | 30 | 30 | | | |
| Number of hours of total student workload (CNPS) | 150 | | | | |
| Form of examination | exam | | | | |
| For group of courses mark (X) final course | X | | | | |
| Number of ECTS points | 5 | | | | |
| including number of ECTS points for practical (P) classes | 1 | 3 | | | |
| including number of ECTS points for direct teacher-student contact (BK) classes | 3 | | | | |

**PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES**

1 Student has a basic knowledge of the calculus, algebra and the probability theory.
2 Student has a basic knowledge of game theory.

**SUBJECT OBJECTIVES**

C1. Basic knowledge of Markov decision processes.
C2. Basic knowledge of algorithms allowing to find value functions and optimal policies.
C3. Basic knowledge of simple markovian decision models.
C4. Basic knowledge of stochastic game models.
C5. Basic knowledge of theory and applications of mean field games.
C6. Ability to apply the acquired knowledge to create and analyze dynamic optimization models in various fields of science and technology.

*niepotrzebne skreślić

**SUBJECT EDUCATIONAL EFFECTS**

*The scope of the student's knowledge*:

PEK_W01 Students knows basic concepts of dynamic programming.

PEK_W02. Student knows basics of theory of stochastic games.

PEK_W03. Student knows basics of theory of mean field games.

*The scope of the student's skills*:

PEK_U01 Student is able to find an optimal policy and value function in a simple markovian decision process.

PEK_U02. Student is able to check whether a vector of strategies forms a Nash equilibrium in a given simple stochastic game.

PEK_U03. Student is able to construct an appropriate dynamic model of a given optimization problem.

*The scope of the student's social skills*:

1 Student is able to utilise literature pointed out by the lecturer.

2 Student is able to use computer programs in order to solve some issues.

3 Student understands the necessity of further self-learning.

## Course content

| **Form of activities - lectures** | | **Hours load** |
|---|---|---|
| Lec1 | Introduction to markovian decision processes, the concept of a policy, different optimality criteria, examples of simple models. | 2 |
| Lec2 | Dynamic programming method. Solving models with finite time horizon. Backward induction. | 2 |
| Lec3 | Models with infinite time horizon. The Banach fixed point theorem and its application to a solution of the Bellman equation. | 2 |
| Lec4 | Algorithms applied to infinite time horizon models: value iteration, policy improvement, LP. | 4 |
| Lec5 | Markov decision processes with risk sensitive payoff criteria. Other payoff criteria. | 2 |
| Lec6 | Specific models. | 2 |
| Lec7 | Two-person zero-sum discounted stochastic games. The theorem of Shapley. | 4 |
| Lec8 | Nonzero-sum discounted stochastic games. | 2 |
| Lec9 | Stochastic games with other payoff criteria. | 2 |
| Lec10 | Applications of stochastic games in economics and engineering. | 2 |
| Lec11 | Mean field games. The existence of solutions. Relation with games with a finite number of players. Examples of applications in economics and engineering. | 4 |
| Lec12 | Summary and exam. | 2 |
| | **Total load (in hours)** | **30** |

| **Form of activities – classes, practice** | | **Hours load** |
|---|---|---|
| Tu1 | Markov chains. | 2 |
| Tu2 | Solving different markovian decision models. | 14 |
| Tu3 | Solving different stochastic game models. | 14 |
| | Total load (in hours) | **30** |

| TOOLS FOR TEACHING |
|---|
| 1 Lecture - traditional method.<br>2 Exercise and accounting problems - the traditional method.<br>3 Consultation.<br>4 Student's own work - preparing to exercise and test. |

**OCENA OSIĄGNIĘCIA PRZEDMIOTOWYCH EFEKTÓW KSZTAŁCENIA**

| **Evaluation** (F – forming (during semester), P – concluding (at semester end) | Educational effect number | Way of evaluating educational effect achievement |
|---|---|---|
| F1 | PEK_W01,PEK_W02, PEK_W03, PEK_U01,PEK_U02, PEK_U03,PEK_K01, PEK_K02 | oral presentations, quizzes |
| F2 | PEK_W01,PEK_W02, PEK_U01,PEK_U02, PEK_U03,PEK_K01, PEK_K02 | exam |
| P=0,5*F1+0,5*F2 | | |

| PRIMARY AND SECONDARY LITERATURE |
|---|
| **PRIMARY LITERATURE**<br>M. Puterman, Markov decision processes, Wiley 1994.<br>N. Stockey, R. Lucas, E. Prescott, Recursive methods in economic dynamics, Harvard University Press, 1989.<br>A. Haurie, J.B. Krawczyk, G. Zaccour. Games and Dynamic Games. World Scientific, 2012.<br>**SECONDARY LITERATURE**<br>H, Tijms, A first course in stochastic models, Wiley 2003.<br>B. Jovanovic and R. W. Rosenthal. Anonymous sequential games. Journal of Mathematical Economics, 17:77–87, 1988.<br>O. Gueant, J-M. Lasry, P-L. Lions, Mean field games and applications. W R. Carmona et al., editor, Paris Princeton Lectures in Mathematical Finance IV, Lecture Notes in Mathematics v.2003. Springer Verlag, 2010. |
| **SUBJECT SUPERVISOR (NAME AND SURNAME, E-MAIL ADDRESS)** |
| Dr hab. inż. Anna Jaskiewicz *(Anna.Jaskiewicz@pwr.edu.pl)*<br>Dr Piotr Więcek ***(****Piotr.Wiecek@pwr.edu.pl)* |

MATRIX OF CORRELATION BETWEEN EDUCATIONAL EFFECTS FOR SUBJECT **ADVANCED TOPICS IN DYNAMIC GAMES MAT001584** AND EDUCATIONAL EFFECTS FOR MAIN FIELD OF STUDY APPLIED MATHEMATICS AND SPECIALIZATION MODELLING, SIMULATION, OPTIMIZATION

| **Subject educational effect** | **Correlation between subject educational effect and educational effects defined for main field of study and specialization (if applicable)**** | **Subject objectives***** | **Programme content***** | **Teaching tool number***** |
|---|---|---|---|---|
| **PEK_W01 (knowledge)** | K2MST_W01, K2MST_mso_W01 | C1, C2, C3, C6 | Lec1, Lec2, Lec3, Lec4, Lec5, Lec6 | 1, 3 |
| **PEK_W02** | K2MST _W02, K2MST_mso_W02 | C4, C6 | Lec7, Lec8, Lec9, Lec10 | 1, 3 |
| **PEK_W03** | K2MST _W12, K2MST _W13, K2MST _W17 K2MST_mso_W03 | C5, C6 | Lec11 | 1, 3 |
| **PEK_U01 (skills)** | K2MST _U04, K2MST _U05, K2MST _U07, K2MST_mso_U01 | C1, C2, C3 | Tu1, Tu2 | 2, 3, 4 |
| **PEK_U02** | K2MST _U08, K2MST _U10, K2MST _U13, K2MST_mso_U02 | C4 | Tu3 | 2, 3 ,4 |
| **PEK_U03** | K2MST _U18, K2MST _U23, K2MST_U24 K2MST_U25 K2MST _U26, K2MST _U27 K2MST_mso_U03 | C6 | Tu2, Tu3 | 2, 3 ,4 |
| **PEK_K01 (competences)** | K2MST _K01, K2MST_mso_K01 | C1, C2, C3, C4, C5, C6 | Lec1-Lec11, Tu1-Tu3 | 1, 2, 3, 4 |
| **PEK_K02** | K2MST _K04, K2MST _K05, K2MST_mso_K02 | C1, C2, C3, C4, C5, C6 | Lec1-Lec11, Tu1-Tu3 | 1, 2, 3, 4 |
| PEK_K03 | K2MST _K07 | C1, C2, C3, C4, C5, C6 | Lec1-Lec11, Tu1-Tu3 | 1, 2, 3, 4 |

** - z tabeli powyżej

Zał. nr 4 do ZW 64/2012

FACULTY OF PURE AND APPLIED MATHEMATICS

**SUBJECT CARD**

**Name in Polish: Badania Operacyjne**
**Name in English: Operations Research**
**Main field of study (if applicable):** APPLIED MATHEMATICS
**Specialization (if applicable): MODELLING, SIMULATION, OPTIMIZATION**
**Level and form of studies: ~~1st/~~ 2nd* level, full-time / ~~part-time~~***
**Kind of subject: ~~obligatory~~ / optional / ~~university-wide~~***
**Subject code MAT001585**
**Group of courses YES / ~~NO~~***

| | Lecture | Classes | Laboratory | Project | Seminar |
|---|---|---|---|---|---|
| Number of hours of organized classes in University (ZZU) | 30 | | 30 | | |
| Number of hours of total student workload (CNPS) | 150 | | | | |
| Form of crediting | Crediting with grade | | | | |
| For group of courses mark (X) final course | X | | | | |
| Number of ECTS points | 5 | | | | |
| including number of ECTS points for practical (P) classes | 1 | | 3 | | |
| including number of ECTS points for direct teacher-student contact (BK) classes | 3 | | | | |

*delete as applicable

**PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES**

1. Student knows and can apply basic notions of linear algebra and logic.
2. Student knows basics of computer programming.

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**SUBJECT OBJECTIVES**

C1 Learning of basic mathematical models supporting decision-making.
C2 Learning of basic algorithms used in operations research
C3 Acquisition of abilities in constructing mathematical models for real problems.
C4 Acquisition of abilities in implementing models in a mathematical modeling language
C5 Acquisition of abilities in presenting and interpreting solutions of the constructed models.

**SUBJECT EDUCATIONAL EFFECTS**

relating to knowledge the student:
PEK_W01 has in-depth knowledge of linear programming
PEK_W02 knows basic models and algorithms used in operations research.

relating to skills the student:
PEK_U01 can build mathematical models for real problems
PEK_U02 can implement mathematical models using a mathematical modeling language

relating to social competences the student:
PEK_K01 can present problem solutions to non-mathematicians in an understandable way.

**PROGRAMME CONTENT**

| **Form of classes - lecture** | | **Number of hours** |
|---|---|---|
| Lec1 | Introduction to operations research. Formulation of the linear programming problem | 2 |
| Lec2 | Building mathematical models (1) | 2 |
| Lec3 | Building mathematical models (2) | 2 |
| Lec4 | Building mathematical models (3) | 2 |
| Lec5 | The simplex algorithm for linear programming. | 2 |
| Lec6 | Duality and sensitivity analysis in linear programming | 2 |
| Lec7 | Algorithms for integer linear programming. | 2 |
| Lec8 | Minimum cost flow problem – applications and mathematical properties | 2 |
| Lec9 | Network simplex algorithm | 2 |
| Lec10 | The shortest (longest) path problem – applications and algorithms | 2 |
| Lec11 | The maximum flow problem – applications and algorithms | 2 |
| Lec12 | The assignment, minimum spanning tree and traveling salesperson problems – applications and algorithms | 2 |
| Lec13 | Elements of computational complexity, NP-hard combinatorial optimization problems and limitations of modern computational techniques. | 2 |
| Lec14 | Multiobjective programming | 2 |
| Lec15 | Written test | |
| | Total hours | **30** |

| **Form of classes - Class** | | **Number of hours** |
|---|---|---|
| La1 | Introduction to MathProg (AMPL) language | 2 |
| La2 | Building and implementing linear programming models for chosen problems | 4 |
| La3 | Building and implementing integer linear programming models for chosen problems | 8 |

| | | |
|---|---|---|
| La4 | Building and implementing models for the minimum cost flow problem and its variants | 4 |
| La5 | Building and implementing models for various variants of the traveling salesperson problem | 2 |
| La6 | Building and implementation models for chosen combinatorial optimization problems | 4 |
| La7 | Building and implementing models for chosen multiobjective problems | 4 |
| La8 | Written test | 2 |
| | Total hours | **30** |

**TEACHING TOOLS USED**

N1. Lecture – computer presentation and traditional method
N2. Laboratory – building models for chosen problems and implementation of the models using the AMPL language

**EVALUATION OF SUBJECT EDUCATIONAL EFFECTS ACHIEVEMENT**

| **Evaluation** (F – forming (during semester), P – concluding (at semester end) | Educational effect number | Way of evaluating educational effect achievement |
|---|---|---|
| F1 | PEK_W01<br>PEK_W02 | Written test (lecture) |
| F2 | PEK_U01<br>PEK_U02<br>PEK_K01 | Written test (laboratory) |
| P=0.5*F1+0.5*F2 | | |

**PRIMARY AND SECONDARY LITERATURE**

**PRIMARY LITERATURE:**


1 H. A. Taha. Operations research. An introduction. Pearson Eduction 2007.
2 F.S. Hillier, G. J. Lieberman. Introduction to operations research. Mc. Graw Hill 2001.
3 B. Kolman, R.E. Beck. Elementary linear programming with applications. Elsevier Science 1995.


**SECONDARY LITERATURE:**


4 A. Shrijver. Theory of linear and integer programming. J. Wiley & Sons 1999.
5 M.S. Bazaraa, J. J. Jarvis, H. D. Sherali. Linear programming and network flows. J. Wiley & Sons 2010.
6 R. Ahuja, T. Magnanti, J. Orlin. Network flows. Theory algorithms and applications. Prentice Hall 1993.
7 R. Fourer, D.M. Gay, B.W. Kernighan. AMPL. A modeling language for mathematical programming, free e-book: *http://ampl.com/resources/the-ampl-book/chapter-downloads/*


**SUBJECT SUPERVISOR (NAME AND SURNAME, E-MAIL ADDRESS)**


**Dr hab. inż. Adam Kasperski (adam.kasperski@pwr.edu.pl)**

MATRIX OF CORRELATION BETWEEN EDUCATIONAL EFFECTS FOR SUBJECT **OPERATIONS RESEARCH MAT001585** AND EDUCATIONAL EFFECTS FOR MAIN FIELD OF STUDY APPLIED MATHEMATICS AND SPECIALIZATION **MODELLING, SIMULATION, OPTIMIZATION**

| Subject educational effect | Correlation between subject educational effect and educational effects defined for main field of study and specialization (if applicable)** | Subject objectives*** | Programme content*** | Teaching tool number*** |
|---|---|---|---|---|
| **PEK_W01 (knowledge)** | K2MST_W04<br>K2MST_W08,<br>K2MST_mso_W01 | C1, C2 | Lec5-Lec14 | 1 |
| **PEK_W02** | K2MST_W11, K2MST_W21<br>K2MST_mso_W02<br>K2MST_mso_W03 | C1, C2 | Lec1-Lec4<br>Lec8-Lec12 | 1 |
| **PEK_U01 (skills)** | K2MST_U10<br>K2MST_U15,<br>K2MST_mso_U01 | C3, C4 | Lec1-Lec4<br>La1-La8 | 1,2 |
| **PEK_U02** | K2MST_U24<br>K2MST_U25<br>K2MST_mso_U02<br>K2MST_mso_U03 | C3, C4 | La1-La8 | 2 |
| **PEK_K01 (competences)** | K2MST_K05<br>K2MST_mso_K01<br>K2MST_mso_K02 | C5 | La1-La8 | 2 |

** - enter symbols for main-field-of-study/specialization educational effects

*** - from table above

**FACULTY OF PURE AND APPLIED MATHEMATICS**
**SUBJECT CARD**

Name in Polish: **Optymalne sterowanie**
**Name in English: Optimal control**
**Main field of study (if applicable): APPLIED MATHEMATICS**
**Specialization (if applicable): MODELLING, SIMULATION, OPTIMIZATION**
**Level and form of studies: ~~1st~~/ 2nd* level, full-time / ~~part-time~~***
**Kind of subject: ~~obligatory /~~ optional ~~/ university-wide~~***
**Subject code MAT001586**
**Group of courses YES / ~~NO~~***

| | Lecture | Classes | Laboratory | Project | Seminar |
|---|---|---|---|---|---|
| Number of hours of organized classes in University (ZZU) | 30 | | 30 | | |
| Number of hours of total student workload (CNPS) | 150 | | | | |
| Form of crediting | Examination / ~~crediting with grade~~* | Examination / crediting with grade* | Examination / crediting with grade* | Examination / crediting with grade* | Examination / crediting with grade* |
| For group of courses mark (X) final course | X | | | | |
| Number of ECTS points | 5 | | | | |
| including number of ECTS points for practical (P) classes | 1 | | 3 | | |
| including number of ECTS points for direct teacher-student contact (BK) classes | 3 | | | | |

**PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES**

The student has basic knowledge of calculus, algebra and the probability theory.

**SUBJECT OBJECTIVES**

C1 Understanding the concepts and methods of control.
C2 Understanding the wording optimal control tasks.
C3 Knowledge of the backgrounds for the analysis of dynamic systems.
C4 Understanding models and analysis of stochastic control systems.
C5 Application of acquired knowledge to create and analyze mathematical models to solve theoretical and practical problems in various fields of science and technology.

**SUBJECT EDUCATIONAL EFFECTS**

*The scope of the student's knowledge*:

1. Student knows the formulation of operational research problems.
2. He recognizes situations that require the application of operations research methods to solve practical problems.
3. He knows the limitations of analytical methods and the possibility of numerical analysis of dynamic models.
4. He knows the stochastic methods in operations research.

*The scope of the student's skills*:

C1 Student is able to formulate modeling task for analysis in a convenient form.
C2 He can use the appropriate algorithm to solve tasks in the operational research.
C3 Student is able to recognize issues that competent optimization methods are based on the use of stochastic camera.

*The scope of the student's social skills*:

PEK_K01 The student is able to find and use the recommended literature course and independently acquire knowledge
PEK_K02 The student is able to use the basic tools for the analysis of mathematical models
PEK_K03 The student understands the need for systematic and independent work on mastery of course material.

| Course content | | |
|---|---|---|
| **Form of activities - lectures** | | **Hours load** |
| Wy1 | Deterministic control system with discrete time. Algorithm of dynamic programming. | 2 |
| Wy2 | Processes with discrete time. Markov chains. Conditional expectation. Martingales and Markov times. | 2 |
| Wy3 | Markov decision processes. Bellman equation. | 2 |
| Wy4 | Introduction to models with infinite horizon. Markov decision models with discounted payments, minimizing the average cost per unit and other criteria. | 4 |
| Wy5 | Applications Markov decision processes in the reliability theory, the renewal theory, the queue theory. | 2 |
| Wy6 | Optimal control of the continuous time. The Hamilton-Jacobi-Bellman equation. | 2 |
| Wy7 | Linear systems with quadratic cost function and a complete state observation. The inventory control systems. | 2 |
| Wy8 | Systems with uncertain state observation. Iterative determination of the value functions. | 2 |
| Wy9 | The approximated solution of the Bellman equation. | 2 |
| Wy10 | Optimal stopping of finite sequences. | 2 |
| Wy11 | Optimal stopping of finite Markov sequences. Examples. | 2 |
| Wy12 | Infinite horizon optimal stopping problem. | 2 |
| Wy13 | The disorder detection problem. | 2 |
| Wy14 | Suboptimal solutions of operation models. Adaptive systems. | 2 |
| | **Total load (in hours)** | **30** |

| **Form of activities: classes, practice** | | **Number of hours** |
|---|---|---|
| Ćw1 | Examples of deterministic control systems with discrete time. | 2 |
| Ćw2 | Properties of Markov chains and their analysis. Checking stationarity and ergodicity of stochastic sequences. Classification of states. Conditional expectation. Martingales and Markov moments. | 2 |
| Ćw3 | Markov decision process for selected practical problems. Analysis of the Bellman equation for the constructed MDPs. | 2 |

| | | |
|---|---|---|
| Ćw4 | Investigation of infinite horizon models. Markov decision models with discounted payoffs, the average cost per unit, and other criteria. | 4 |
| Ćw5 | Applications Markov decision processes in the reliability theory, the renewal theory, the queue theory-examples. | 2 |
| Ćw6 | Optimal control of the continuous time. The Hamilton-Jacobi-Bellman equation. | 2 |
| Ćw7 | Linear systems with quadratic cost function and a complete state observation. The inventory control systems. | 2 |
| Ćw8 | Systems with uncertain state observation. Iterative determination of the value functions. | 2 |
| Ćw9 | The approximated solution of the Bellman equation. | 2 |
| Ćw10 | Optimal stopping of finite sequences. | 2 |
| Ćw11 | Optimal stopping of finite Markov sequences. Examples. | 4 |
| Ćw12 | Analysis of selected disorder problems. | 2 |
| Ćw13 | Suboptimal solutions. Adaptive systems. | 2 |
| | Total hours | **30** |

| **TOOLS FOR TEACHING** |
|---|
| 1 Lecture - traditional method.<br>2 Exercise and accounting problems - the traditional method.<br>3 Consultation.<br>4 Student's own work - preparing to exercise and test. |

**EVALUATION OF SUBJECT EDUCATIONAL EFFECTS ACHIEVEMENT**

| **Evaluation** (F – forming (during semester), P – concluding (at semester end) | Educational effect number | Way of evaluating educational effect achievement |
|---|---|---|
| F1 | PEK_W01, PEK_W02, PEK_W03<br>PEK_W04, PEK_W05<br>PEK_K01, PEK_K02 | oral presentations, quizzes, tests |
| F2 | PEK_W01, PEK_W02, PEK_W03<br>PEK_W04, PEK_W05<br>PEK_U01, PEK_U02, PEK_U03, PEK_U04<br>PEK_K01, PEK_K02, PEK_K03 | exam |
| P=0,4*F1+0,6*F2 | | |

| **PRIMARY AND SECONDARY LITERATURE** |
|---|
| **PRIMARY LITERATURE:**<br>1 Dimitri P. Bertsekas, Dynamic Programming and Optimal Control, vol. 1, Athena Scientific, Belmont, MA: 2005.<br>2 Dimitri P. Bertsekas, Dynamic Programming and Optimal Control, vol. 2, Athena Scientific, Belmont, MA: 2007.<br>3 Harold Kushner: Wprowadzenie do teorii sterowania stochastycznego. WNT, 1983.<br>4 A.N. Shiryaev. Optimal Stopping Rules. Springer-Verlag, New York, Heidelberg, Berlin, 1978. |

**SECONDARY LITERATURE:**


1 J. P. Aubin, Optima and Equilibria. An Introduction to Nonlinear Analysis, Springer, Berlin 1993.

2 Wayne l. Winston: introduction to mathematical programming: applications and algorithms, 1991.


**SUBJECT SUPERVISOR (NAME AND SURNAME, E-MAIL ADDRESS)**


Dr hab. inż. Anna Jaśkiewicz
Prof. Dr Hab. Eng. Krzysztof Szajowski (krzysztof.szajowski@pwr.edu.pl)


MATRIX OF CORRELATION BETWEEN EDUCATIONAL EFFECTS FOR SUBJECT **Optimal Control MAT001586** AND EDUCATIONAL EFFECTS FOR MAIN FIELD OF STUDY APPLIED MATHEMATICS AND SPECIALIZATION MODELLING, SIMULATION, OPTIMIZATION

| AND SPECIALIZATION ….. **Subject educational effect** | **Correlation between subject educational effect and educational effects defined for main field of study and specialization (if applicable)**** | **Subject objectives***** | **Programme content***** | **Teaching tool number***** |
|---|---|---|---|---|
| PEK_W01<br>PEK_W02<br>PEK_W03<br>PEK_W04 | K2MST_W01,<br>K2MST_W02,<br>K2MST_W03,<br>K2MST_W06,<br>K2MST_W07,<br>K2MST_W08,<br>K2MST_W10<br>K2MST_mso_W01<br>K2MST_mso_W02<br>K2MST_mso_W03 | C1—C6 | Wy1—Wy9 | 1,3,4 |
| PEK_U01<br>PEK_U02<br>PEK_U03 | K2MST_U01,<br>K2MST_U02,<br>K2MST_U03,<br>K2MST_U15,<br>K2MST_U16,<br>K2MST_U17,<br>K2MST_U18,<br>K2MST_U19<br>K2MST_U24<br>K2MST_U25<br>K2MST_mso_U01<br>K2MST_mso_U02<br>K2MST_mso_U03 | C1—C5 | Ćw1-Ćw9 | 2,3,4 |
| PEK_K01<br>PEK_K02<br>PEK_K03 | K2MST_K0,<br>K2MST_K02,<br>K2MST_K03,<br>K2MST_K04,<br>K2MST_K05,<br>K2MST_K06<br>K2MST_K07<br>K2MST_mso_K01<br>K2MST_mso_K02 | C1, C2, C3, C4, C5, C6 | Wy1-Wy14, Ćw1-Ćw9 | 1, 2, 3, 4 |

** - from table above

Zał. nr 4 do ZW 64/2012

FACULTY OF PURE AND APPLIED MATHEMATICS

**SUBJECT CARD**

**Name in Polish WSTĘP DO ANALIZY DUŻYCH WOLUMENÓW DANYCH**

**Name in English INTRODUCTION TO BIG DATA ANALYTICS**

**Main field of study (if applicable):** APPLIED MATHEMATICS

**COMPUTATIONAL MATHEMATICS**

**Level and form of studies: ~~1st~~/ 2nd* level, full-time / ~~part-time*~~**

**Kind of subject: ~~obligatory~~ / optional ~~/ university-wide*~~**

**Subject code MAT001587**

**Group of courses YES ~~/ NO~~***

| | Lecture | Classes | Laboratory | Project | Seminar |
|---|---|---|---|---|---|
| Number of hours of organized classes in University (ZZU) | 30 | | 30 | | |
| Number of hours of total student workload (CNPS) | 90 | | | | |
| Form of crediting | crediting with grade | | | | |
| For group of courses mark (X) final course | X | | | | |
| Number of ECTS points | 5 | | | | |
| including number of ECTS points for practical (P) classes | | | 4 | | |
| including number of ECTS points for direct teacher-student contact (BK) classes | 3 | | | | |

*delete as applicable

**PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES**

Student has basic programming skills.

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**SUBJECT OBJECTIVES**

Searching, extracting, storing and computer-aided analysis of big data. Understanding its impact and relevance in today's society.

**SUBJECT EDUCATIONAL EFFECTS**

relating to knowledge:

PEK_W12 knows how to use programming languages and their scientific modules for big data analysis

relating to skills:

PEK_U12 can perform an analysis of big data by making use of a computer

relating to social competences:

PEK_K06 can, without assistance, search for necessary information in the literature, also in foreign languages

PEK_K02 can accurately formulate questions for deeper understanding of a given topic

| PROGRAMME CONTENT | | |
|---|---|---|
| **Form of classes - lecture** | | **Number of hours** |
| Lec 1 | Introduction to Big Data | 2 |
| Lec 2 | Big data platforms | 2 |
| Lec 3 | Hadoop ecosystem | 4 |
| Lec 4 | Querying big data with Hive | 4 |
| Lec 5 | Big data and machine learning | 4 |
| Lec 6 | In-memory big data platform - Spark | 4 |
| Lec 7 | Linked Big Data | 4 |
| Lec 8 | Big data visualization | 2 |
| Lec 9 | Project presentations | 4 |
| | Total hours | **30** |

| **Form of classes - project** | | **Number of hours** |
|---|---|---|
| Pr1 | Practical Preparation and presentations of projects illustrating methods given in the lectures. | 30 |
| | Total hours | **30** |

## TEACHING TOOLS USED

N1. Lecture – traditional method and presentations
N2. Student partial project presentation and final presentation
N3. Consultations
N4. Student's self work – work related to the project development

## EVALUATION OF SUBJECT EDUCATIONAL EFFECTS ACHIEVEMENT

| **Evaluation** (F – forming (during semester), P – concluding (at semester end) | Educational effect number | Way of evaluating educational effect achievement |
|---|---|---|
| F1 | PEK_W12<br>PEK_U12 | mid-term exams |
| F2 | PEK_U12<br>PEK_K06<br>PEK_K02 | Oral presentations |
| C P==0.5*F1+0.5*F2 | | |

## PRIMARY AND SECONDARY LITERATURE

**PRIMARY LITERATURE:**


1 Flach, Peter, Machine Learning, Cambridge University Press, 2012
2 Holmes, Alex, Hadoop in practice, Manning Publications, 2013
3 Provost, Foster, Facett, Tom, Data Science for Business. What you need to know about data mining and data-analytic thinking, O'Reilly, 2013
4 Loshin, David, Big Data Analytics. From Strategic Planning to Enterprise Integration with Tools, Techniques, NoSQL, and Graph, Morgan Kaufmann, 2013


**SECONDARY LITERATURE:**


5 http://hadoop.apache.org/, http://spark.apache.org/, http://storm.apache.org/, http://kafka.apache.org/
6 deRoos, Dirk, Hadoop for Dummies, For Dummies, 2014


**SUBJECT SUPERVISOR (NAME AND SURNAME, E-MAIL ADDRESS)**

MATRIX OF CORRELATION BETWEEN EDUCATIONAL EFFECTS FOR SUBJECT
**INTRODUCTION TO BIG DATA ANALYTICS MAT001587**
AND EDUCATIONAL EFFECTS FOR MAIN FIELD OF STUDY
**APPLIED MATHEMATICS** AND SPECIALIZATION
**COMPUTATIONAL MATHEMATICS**

| Subject educational effect | Correlation between subject educational effect and educational effects defined for main field of study and specialization (if applicable)** | Subject objectives*** | Programme content*** | Teaching tool number*** |
|---|---|---|---|---|
| **PEK_W12** | K2MIC_W12 | C1 | Lec1-Lec9 | 1,3 |
| **PEK_U12 (skills)** | K2MIC_U21<br>K2MIC_U20<br>K2MIC_U24<br>K2MIC_U25 | C1 | Pr1 | 2,3,4 |
| **PEK_K02**<br>**PEK_K06**<br>**(competences)** | K2MIC_K02<br>K2MIC_K06 | C1 | Lec1-Le9, Pr1 | 1,2,3,4 |

** - enter symbols for main-field-of-study/specialization educational effects
*** - from table above

**FACULTY OF PURE AND APPLIED MATHEMATICS**
**SUBJECT CARD**

Name in Polish: **Teoria optymalizacji**
**Name in English: Optimization Theory**
**Main field of study (if applicable): Applied Mathematics**
**Specialization (if applicable):**
**Level and form of studies: ~~1st/~~ 2nd* level, full-time / ~~part-time~~***
**Kind of subject: obligatory ~~/ optional / university-wide*~~**
**Subject code MAT001588**
**Group of courses YES / ~~NO~~***

| | Lecture | Classes | Laboratory | Project | Seminar |
|---|---|---|---|---|---|
| Number of hours of organized classes in University (ZZU) | 30 | 30 | | | |
| Number of hours of total student workload (CNPS) | 180 | | | | |
| Form of crediting | ~~Examination~~ / crediting with grade* | Examination / crediting with grade* | Examination / crediting with grade* | Examination / crediting with grade* | Examination / crediting with grade* |
| For group of courses mark (X) final course | X | | | | |
| Number of ECTS points | 6 | | | | |
| including number of ECTS points for practical (P) classes | 2 | 2 | | | |
| including number of ECTS points for direct teacher-student contact (BK) classes | 1,5 | 1,5 | | | |

**PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES**

1 The student has basic knowledge of calculus and algebra.

**SUBJECT OBJECTIVES**

1 Student is understanding the concepts and methods of mathematical programming.
2 He knows and understands the formulation of the linear and quadratic programming.
3 He has knowledge of the theoretical background of mathematical programming.
4 He knows the computer methods of mathematical programming.
5 He is able to apply the acquired knowledge to create and analyze mathematical models to solve theoretical and practical study in various fields of science and technology.

**SUBJECT EDUCATIONAL EFFECTS**

*The scope of the student's knowledge*:

1 Student knows the formulation of mathematical programming problems.
2 He has a basic knowledge about the usage and importance of mathematical programming methods.
3 He knows the limitations of analytical methods and the possibility of numerical analysis of optimization problems.

*The scope of the student's skills*:

1 Student is able to formulate mathematical programming problem in a convenient form for analysis.
2 He can use the appropriate algorithm to solve tasks in the mathematical programming.
3 He can apply optimization methods, and analytical methods or numerical analysis, in order to solve practical problems.

*The scope of the student's social skills*:
PEK_K01 The student is able to find and use the recommended literature course and independently acquire knowledge
PEK_K02 The student is able to use the basic tools for the analysis of mathematical models
PEK_K03 The student understands the need for systematic and independent work on mastery of course material.

## Course content

| Form of activities - lectures | | Hours load |
|---|---|---|
| Wy1 | Introduction to mathematical programming. Optimization without constraints. Global and local extremes. Optimality conditions. | 2 |
| Wy2 | Gradient methods. Steepest descent method. Newton's method and its variants. Analysis of convergence. | 6 |
| Wy3 | Linear programming. Geometric interpretation. Simplex algorithm. | 4 |
| Wy4 | Dual problem. Duality theory for linear programming. Sensitivity analysis. | 2 |
| Wy5 | Integer programming. Linear programming relaxation. Branch and bound method. | 2 |
| Wy6 | The theory of Lagrange multipliers. The necessary and sufficient conditions for extreme for constraints in the equality form. Lagrange multipliers in sensitivity analysis. | 4 |
| Wy7 | Constraints in the form of inequality. Optimality conditions of Karush-Kuhn-Tucker. | 2 |
| Wy8 | Quadratic programming. Wolfe's algorithm. | 2 |
| Wy9 | Elements of convex analysis. Projection theorem. Supporting hyperplane theorem. Separating hyperplane theorem. | 2 |
| Wy10 | Optimization on a convex set. Frank-Wolfe's method. Gradient projection method. | 2 |
| Wy11 | Convex programming. Duality for convex programming. Subgradient. Subgradient methods. | 2 |
| | **Total load (in hours)** | **30** |

| Form of activities: classes, practice | | Number of hours |
|---|---|---|
| C6 | Necessary and sufficient optimality conditions. | 2 |
| C7 | Properties of convex functions and convex sets. | 2 |
| C8 | Illustration of gradient methods. | 4 |
| C9 | Simplex method. Practical applications of linear programming. Sensitivity | 8 |

| | | |
|---|---|---|
| | analysis. | |
| C10 | Applications of Lagrange multiplier theory in practical optimization problems. | 6 |
| C11 | Quadratic programming problems. | 4 |
| C12 | Applications of convex analysis in solving optimization problems. | 2 |
| C13 | Test. | 2 |
| | Total hours | **30** |

| **TOOLS FOR TEACHING** |
|---|
| 1 Lecture - traditional method.<br>2 Exercise and accounting problems - the traditional method.<br>3 Consultation.<br>4 Student's own work - preparing to exercise and test. |

**OCENA OSIĄGNIĘCIA EFEKTÓW KSZTAŁCENIA**

| **Evaluation** (F – forming (during semester), P – concluding (at semester end) | Educational effect number | Way of evaluating educational effect achievement |
|---|---|---|
| F1 | PEK_W01, PEK_W02, PEK_W03, PEK_K01, PEK_K02 | oral presentations, quizzes, tests |
| F2 | PEK_W01, PEK_W02, PEK_W03, PEK_U01, PEK_U02, PEK_U03, PEK_K01, PEK_K02, PEK_K03 | exam |
| P=0,4*F1+0,6*F2 | | |

**PRIMARY AND SECONDARY LITERATURE**

**PRIMARY LITERATURE:**


1 S.P. Bradley, A.C. Hax, T.L. Magnanti, Applied Mathematical Programming, Addison-Wesley Publishing Company, 1977
2 D.P. Bertsekas, Nonlinear Programming, Athena Scientific, Belmont, MA: 1999.
3 I. Nykowski, Programowanie liniowe, PWE Warszawa 1980.
4 W. Grabowski, Programowanie matematyczne, PWE Warszawa 1980.
5 R.S. Garfinkel, G.L. Nemhauser, Programowanie całkowitoliczbowe, PWN, 1978.
6 B. Martos, Programowanie nieliniowe, Warszawa: PWN, 1983.


**SECONDARY LITERATURE:**


7 D.P. Bertsekas, A. Nedic, A.E. Ozdaglar, Convex Analysis and Optimization, Athena Scientific, Belmont, MA: 2003.
8 A. Ruszczyński, Nonlinear optimization, Princeton University Press, Princeton, NJ, 2006.
9 R. Dautray, J. L. Lions, Mathematical Analysis and Numerical Methods for Science and Technology, Springer, Berlin 1988-1993.
10 S. Boyd, L. Vanderberghe, Convex Optimization, Cambridge University Press, 2004


**SUBJECT SUPERVISOR (NAME AND SURNAME, E-MAIL ADDRESS)**

Dr hab. inż. Anna Jaśkiewicz (anna.jaskiewicz@pwr.edu.pl)
Dr inż. Piotr Więcek (Piotr.wiecek@pwr.edu.pl)

MATRIX OF CORRELATION BETWEEN EDUCATIONAL EFFECTS FOR SUBJECT **OPTIMIZATION THEORY MAT001588** AND EDUCATIONAL EFFECTS FOR MAIN FIELD OF STUDY **APPLIED MATHEMATICS**

| **Subject educational effect** | **Correlation between subject educational effect and educational effects defined for main field of study and specialization (if applicable)**** | **Subject objectives***** | **Programme content***** | **Teaching tool number***** |
|---|---|---|---|---|
| PEK_W01 **(knowledge)** | K2MST_W01<br>K2MST _W06<br>K2MST_W10<br>K2MST_mso_W01 | C1—C2 | Wy1—Wy11 | 1,3,4 |
| PEK_W02 | K2MST _W02<br>K2MST _W07<br>K2MST_W15<br>K2MST_mso_W02 | C5 | Wy1—Wy6 | 1,3,4 |
| PEK_W03 | K2MST _W03<br>K2MST _W08<br>K2MST_mso_W03 | C3—C4 | Wy1—Wy11 | 1,3,4 |
| PEK_U01 **(skills)** | K2MST_U01<br>K2MST_U11<br>K2MST_mso_U01 | C1—C2, C5 | Ćw1-Ćw9 | 2,3,4 |
| PEK_U02 | K2MST_U19<br>K2MST_U24<br>K2MST_mso_U02 | C4—C5 | Ćw1-Ćw9 | 2,3,4 |
| PEK_U03 | K2MST_U25<br>K2MST_U29<br>K2MST_mso_U03 | C1—C2,<br>C4—C5 | Ćw1-Ćw9 | 2,3,4 |
| PEK_K01 **(competences, social skills)** | K2MST_K01<br>K2MST_K04<br>K2MST_mso_K01 | C1, C2, C3, C4, C5 | Wy1-Wy11, Ćw1-Ćw9 | 1, 2, 3, 4 |
| PEK_K02 | K2MST_K02<br>K2MST_K05<br>K2MST_mso_K02 | C1—C5 | Wy1-Wy11, Ćw1-Ćw9 | 1, 2, 3, 4 |
| PEK_K03 | K2MST_K03<br>K2MST_K06<br>K2MST_K07 | C1—C5 | Wy1-Wy11, Ćw1-Ćw9 | 1, 2, 3, 4 |

** - from table above

Zał. nr 4 do ZW 64/2012

**FACULTY OF PURE AND APPLIED MATHEMATICS**
**SUBJECT CARD**

**Name in Polish MODELOWANIE AGENTOWE UKŁADÓW ZŁOŻONYCH**
**Name in English AGENT-BASED MODELLING OF COMPLEX SYSTEMS**
**Main field of study (if applicable): APPLIED MATHEMATICS**
**Level and form of studies: ~~1st~~/ 2nd* level, full-time / ~~part-time*~~**
**Kind of subject: obligatory ~~/ optional / university-wide*~~**
**Subject code MAT001589**
**Group of courses YES / NO***

| | Lecture | Classes | Laboratory | Project | Seminar |
|---|---|---|---|---|---|
| Number of hours of organized classes in University (ZZU) | 30 | | 30 | | |
| Number of hours of total student workload (CNPS) | 150 | | | | |
| Form of crediting | Examination | | | | |
| For group of courses mark (X) final course | X | | | | |
| Number of ECTS points | 5 | | | | |
| including number of ECTS points for practical (P) classes | 2 | | 2 | | |
| including number of ECTS points for direct teacher-student contact (BK) classes | 1,5 | | 1,5 | | |

*delete as applicable

**PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES**

1 Student has the standard knowledge of computational methods in mathematics.
2 Student has basic programming skills.

\

**SUBJECT OBJECTIVES**

Analysis of complex systems by making use of agent-based modelling methods.

**SUBJECT EDUCATIONAL EFFECTS**

relating to knowledge:
K2MIC_W08 knows advanced computational methods and understand their limitations

K2MIC_W09 knows basic stochastic modelling methods in financial and actuarial mathematics or in science

relating to skills:
K2MIC_U23 can construct and perform computer simulations and simple experiments, can interpret obtained results and draw conclusions

relating to social competences:
K2MIC_K06 can, without assistance, search for necessary information in the literature, also in foreign languages

K2MIC_K02 can accurately formulate questions for deeper understanding of a given topic

| PROGRAMME CONTENT | | |
|---|---|---|
| **Form of classes - lecture** | | **Number of hours** |
| Lec 1 | Introduction to agent-based modelling | 2 |
| Lec 2 | Introduction to agent-based modelling | 2 |
| Lec 3 | Creating simple agent-based models | 2 |
| Lec 4 | Creating simple agent-based models | 2 |
| Lec 5 | Exploring and extending agent-based models | 2 |
| Lec 6 | Exploring and extending agent-based models | 2 |
| Lec 7 | Exploring and extending agent-based models | 2 |
| Lec 8 | Exploring and extending agent-based models | 2 |
| Lec 9 | Components of agent-based models | 2 |
| Lec 10 | Components of agent-based models | 2 |
| Lec 11 | Analyzing agent-based simulations | 2 |
| Lec 12 | Analyzing agent-based simulations | 2 |
| Lec 13 | Verification and validation of agent-based models | 2 |
| Lec 14 | Computational roots of agent-based modelling | 2 |
| Lec 15 | Models of natural and social complex systems - examples | 2 |
| | Total hours | **30** |

| **Form of classes - laboratory** | | **Number of hours** |
|---|---|---|
| La 1 | Practical introduction to Python modules for agent-based modelling | 2 |
| La 2 | Practical introduction to Netlogo | 2 |
| La 3 | Simple agent-based models (life, ant, heroes and cowards models) | 4 |
| La 4 | Analysis of existing models (fire, segregation and El Farol models) | 8 |
| La 5 | SI epidemics model – implementation and analysis | 4 |
| La 6 | SIR epidemics model – implementation and analysis | 2 |
| La 7 | Voter and q-voter models – implementation and analysis | 8 |
| | Total hours | **30** |

| **TEACHING TOOLS USED** |
|---|
| N1. Lecture – traditional method and presentations<br>N2. Problem and computing laboratory – using computer based methods<br>N3. Consultations<br>N4. Student's self work – preparation for the laboratory |

**EVALUATION OF SUBJECT EDUCATIONAL EFFECTS ACHIEVEMENT**

| **Evaluation** (F – forming (during semester), P – concluding (at semester end) | Educational effect number | Way of evaluating educational effect achievement |
|---|---|---|
| F1 | K2MIC_W08 | exam |

| | | |
|---|---|---|
| | K2MIC_W09 | |
| F2 | K2MIC_U23<br>K2MIC_K02<br>K2MIC_K06 | Oral presentations |
| C P==0.5*F1+0.5*F2 | | |

**PRIMARY AND SECONDARY LITERATURE**

**PRIMARY LITERATURE:**

1 Uri Wilensky, William Rand, "An Introduction to Agent-Based Modeling"

2 Steven F. Railsback, Volker Grimm, "Agent-Based and Individual-Based Modeling: A Practical Introduction"

**SECONDARY LITERATURE:**

1 Robert Siegfried, „Modeling and Simulation of Complex Systems: A Framework for Efficient Agent-Based Modeling and Simulation"

**SUBJECT SUPERVISOR (NAME AND SURNAME, E-MAIL ADDRESS)**

MATRIX OF CORRELATION BETWEEN EDUCATIONAL EFFECTS FOR SUBJECT **AGENT-BASED MODELLING OF COMPLEX SYSTEMS MAT001589** AND EDUCATIONAL EFFECTS FOR MAIN FIELD OF STUDY **APPLIED MATHEMATICS AND COMPUTATIONAL MATHEMATICS**

| Subject educational effect | Correlation between subject educational effect and educational effects defined for main field of study and specialization (if applicable)** | Subject objectives*** | Programme content*** | Teaching tool number*** |
|---|---|---|---|---|
| **PEK_W08<br>PEK_W09<br>(knowledge)** | K2MST_W08<br>K2MST_W09<br>K2MST_W11<br>K2MST_cm_W01<br>K2MST_cm _W02<br>K2MST_cm _W03 | C1 | Lec1-Lec15 | 1,3 |
| **PEK_U18 (skills)** | K2MST_U17<br>K2MST_U18<br>K2MST_U24<br>K2MST_U25<br>K2MST_cm _U01<br>K2MST_cm_U02<br>K2MST_cm_U03 | C1 | La1-La7 | 2,3,4 |
| **PEK_K02<br>PEK_K06<br>(competences)** | K2MST_K02<br>K2MST_K06<br>K2MST_cm_K01<br>K2MST_cm_K02 | C1 | Lec1-Lec15,<br>La1-La7 | 1,2,3,4 |

** - enter symbols for main-field-of-study/specialization educational effects

*** - from table above

Zał. nr 4 do ZW 64/2012

FACULTY OF PURE AND APPLIED MATHEMATICS

**SUBJECT CARD**

**Name in Polish: Praca dyplomowa**
**Name in English: Diploma thesis**
**Main field of study (if applicable):** APPLIED MATHEMATICS
**Specialization (if applicable): FINANCIAL AND ACTUARIAL MATHEMATICS; MATHEMATICS FOR INDUSTRY AND COMMERCE; COMPUTATIONAL MATHEMATICS; MODELLING, SIMULATION, OPTIMIZATION**
**Level and form of studies: ~~1st/~~ 2nd* level, full-time / ~~part-time~~***
**Kind of subject: obligatory ~~/ optional~~ / ~~university-wide~~***
**Subject code MAT001590**
**Group of courses ~~YES~~ / NO***

| | Lecture | Classes | Laboratory | Project | Seminar |
|---|---|---|---|---|---|
| Number of hours of organized classes in University (ZZU) | | | | | 30 |
| Number of hours of total student workload (CNPS) | | | | | 690 |
| Form of crediting | Examination / crediting with grade* | Examination / crediting with grade* | Examination / crediting with grade* | Examination / crediting with grade* | ~~Examination~~ / crediting with grade* |
| For group of courses mark (X) final course | | | | | |
| Number of ECTS points | | | | | 23 |
| including number of ECTS points for practical (P) classes | | | | | 23 |
| including number of ECTS points for direct teacher-student contact (BK) classes | | | | | 1 |

*delete as applicable

**PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES**

1. Student has the advanced knowledge and skills in the field of mathematical analysis, functional analysis and the theory of differential equations
2. He has deeper knowledge and skills in the field of probability theory, mathematical statistics and the theory of stochastic processes.

\

**SUBJECT OBJECTIVES**

C1 Getting to know new developments and methods used in various applications of mathematics.

**SUBJECT EDUCATIONAL EFFECTS**

relating to knowledge:
PEK_W01 knows the basic models and methods used in various applications of mathematics
PEK_W02 knows the basics of stochastic modeling

relating to skills:
PEK_U01 able to construct basic mathematical models used in various fields

relating to social competences:
PEK_K01 can benefit from the scientific literature (including in foreign languages), including reaching the source materials and make them review

**TEACHING TOOLS USED**

N1. Student's own work - searching for information, writing thesis analysis of real data
N2. Consultations

**EVALUATION OF SUBJECT EDUCATIONAL EFFECTS ACHIEVEMENT**

| **Evaluation** (F – forming (during semester), P – concluding (at semester end) | Educational effect number | Way of evaluating educational effect achievement |
|---|---|---|
| F1 | PEK_W01<br>PEK_W02<br>PEK_U01<br>PEK_K01 | evaluation of the student's self work, the assessment of the thesis |
| P=F1 | | |

**PRIMARY AND SECONDARY LITERATURE**

**SUBJECT SUPERVISOR (NAME AND SURNAME, E-MAIL ADDRESS)**

**Prof. dr hab. Aleksander Weron** (Aleksander.Weron@pwr.edu.pl)
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MATRIX OF CORRELATION BETWEEN EDUCATIONAL EFFECTS FOR SUBJECT **DIPLOMA THESIS** MAT001590 AND EDUCATIONAL EFFECTS FOR MAIN FIELD OF STUDY APPLIED MATHEMATICS AND SPECIALIZATION **FINANCIAL AND ACTUARIAL MATHEMATICS; MATHEMATICS FOR INDUSTRY AND COMMERCE; COMPUTATIONAL MATHEMATICS; MODELLING, SIMULATION, OPTIMIZATION**

| Subject educational effect | Correlation between subject educational effect and educational effects defined for main field of study and specialization (if applicable)** | Subject objectives*** | Programme content*** | Teaching tool number*** |
|---|---|---|---|---|
| **PEK_W01 (knowledge)** | K2MST_W03<br>K2MST_W04<br>K2MST_W05<br>K2MST_W09 | C1 | Not applicable | 1, 2 |
| **PEK_W02** | K2MST_W12<br>K2MST_W14<br>K2MST_W20<br>K2MST_W21 | C1 | Not applicable | 1, 2 |
| **PEK_U01 (skills)** | K2MST_U02<br>K2MST_U03<br>K2MST_U04<br>K2MST_U05<br>K2MST_U07<br>K2MST_U10<br>K2MST_U12<br>K2MST_U13<br>K2MST_U14<br>K2MST_U15<br>K2MST_U21<br>K2MST_U24<br>K2MST_U25<br>K2MST_U26<br>K2MST_U28<br>K2MST_U30 | C1 | Not applicable | 1, 2 |
| **PEK_K01 (competences)** | K2MST_K06 | C1 | Not applicable | 1, 2 |

** - enter symbols for main-field-of-study/specialization educational effects

*** - from table above

Zał. nr 4 do ZW

**FACULTY OF PURE AND APPLIED MATHEMATICS**
**SUBJECT CARD**

**Name in Polish: SEMINARIUM DYPLOMOWE**
**Name in English: Diploma Seminar**
Main field of study (if applicable): APPLIED MATHEMATICS
**Specialization (if applicable): FINANCIAL AND ACTUARIAL MATHEMATICS; MATHEMATICS FOR INDUSTRY AND COMMERCE; COMPUTATIONAL MATHEMATICS; MODELLING, SIMULATION, OPTIMIZATION**
**Level and form of studies: ~~1st/~~ 2nd* level, full-time / ~~part-time~~***
**Kind of subject: obligatory ~~/ optional /~~ ~~university-wide~~***
**Subject code MAT001591**
**Group of courses ~~YES~~ / NO***

| | Lecture | Classes | Laboratory | Project | Seminar |
|---|---|---|---|---|---|
| Number of hours of organized classes in University (ZZU) | | | | | 30 |
| Number of hours of total student workload (CNPS) | | | | | 60 |
| Form of crediting | | | | | ~~Examination~~ / crediting with grade* |
| For group of courses mark (X) final course | | | | | |
| Number of ECTS points | | | | | 2 |
| including number of ECTS points for practical (P) classes | | | | | 2 |
| including number of ECTS points for direct teacher-student contact (BK) classes | | | | | 1 |

**PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES**

1 Student has an advanced knowledge and skills in the field of calculus, functional analysis and the theory of differentia equations.
2 She has got a thorough knowledge and skills in the field of probability, mathematical statistics and the theory of stochastic processes.

**SUBJECT OBJECTIVES**

C1 Learning about achievements and new methods used in various applications of mathematics.

*delete as inapplicable

**SUBJECT EDUCATIONAL EFFECTS**

Relating to knowledge:

PEK_W01 knows fundamental models and methods used in various applications of mathematics

PEK_W02 knows the fundamentals of stochastic modeling

Relating to skills:

PEK_U01 can build basic mathematical models, used in various disciplines

Relating to social competences:

PEK_K01 can use the scientific literature (also in foreign languages), including finding source information and browse through articles

| **Form of classes - seminar** | | **Number of hours** |
|---|---|---|
| Se1 | Master thesis results presentations. | 30 |
| | Total hours | **30** |

**TEACHING TOOLS USED**

[3] Problem Seminar, presentation, problem lecture, informative lecture

[4] Student's self-work – preparation for the seminar

**EVALUATION OF SUBJECT EDUCATIONAL EFFECTS ACHIEVEMENT**

| **Evaluation** (F – forming (during semester), P – concluding (at semester end) | Educational effect number | Way of evaluating educational effect achievement |
|---|---|---|
| F1 | PEK_W01<br>PEK_W02<br>PEK_U01<br>PEK_K01 | Evaluation of the presentation, informative or problem lecture prepared by the student |
| P=F1 | | |

**PRIMARY AND SECONDARY LITERATURE**

**SUBJECT SUPERVISOR (NAME AND SURNAME, E-MAIL ADDRESS)**

**Prof. dr hab. Aleksander Weron** (Aleksander.Weron@pwr.edu.pl)
**Prof. dr hab. Wojciech Okrasiński** (Wojciech.Okrasinski@pwr.edu.pl)

MATRIX OF CORRELATION BETWEEN EDUCATIONAL EFFECTS FOR SUBJECT **DIPLOMA SEMINAR 3 MAT001591** AND EDUCATIONAL EFFECTS FOR MAIN FIELD OF STUDY APPLIED MATHEMATICS AND SPECIALIZATION: **FINANCIAL AND ACTUARIAL MATHEMATICS; MATHEMATICS FOR INDUSTRY AND COMMERCE; COMPUTATIONAL MATHEMATICS; MODELLING, SIMULATION, OPTIMIZATION**

| Subject educational effect | Correlation between subject educational effect and educational effects defined for main field of study and specialization (if applicable) | Subject objectives** | Programme content** | Teaching tool number** |
|---|---|---|---|---|
| **PEK_W01 (knowledge)** | K2MST_W03 | C1 | Se1 | 1, 2 |
| **PEK_W02** | K2MST_W09 | C1 | Se1 | 1, 2 |
| **PEK_U01 (skills)** | K2MST_U15<br>K2MST_U24<br>K2MST_U25 | C1 | Se1 | 1, 2 |
| **PEK_K01 (competences)** | K2MST_K06 | C1 | Se1 | 1, 2 |

** - from the table above