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

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## SUBJECT OBJECTIVES
C1  Learning of statistical criteria for assessing the quality of statistical estimation
C2 Learning basic parametric estimation methods and their properties.
C3 Learning basic non-parametric estimation methods and their properties.
C4 Ability to program advanced statistical methods.
C5 Ability to carry out simulation studies.
C6 Ability to evaluate properties of statistical methods based on simulation studies.
C7 Mastering of English vocabulary in the field of estimation methods .
C8 Report 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<br>N2. Laboratory - self development of programs for simulation, reports from analyses<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 | All subject effects of the course | Reports and activity during the laboratory. |
| F2 | PEK_W01 PEK_W02 PEK_W03 PEK_W04 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 K2MST_cm_W01 | C2 | Lec 1-Lec 4, Lec 13, Lec 14 Lab 1-Lab 3, Lab 6, Lab 7 | 1-4 |
| **PEK_W02** | K2MST_W15 K2MST_cm _W02 | C3 | Lec 5-Lec 4, Lab 4-Lab 7 | 1-4 |
| **PEK_W03** | K2MST_W16 K2MST_cm _W03 | C1 | Lec 1-Lec 14, Lab 1-Lab 7 | 1-4 |
| **PEK_W04** | K2MST_W18 | C5,C6 | Lec 2-Lec 14, Lab 1-Lab 7 | 1-4 |
| **PEK_W05** | K2MST_W13 | C7, C8 | Lec 1-Lec 14, Lab 1-Lab 7 | 1-4 |
| **PEK_W06** | K2MST_W12 | C4, C5, C6 | Lec 2-Lec 14, Lab 1-Lab 7 | 1-4 |
| **PEK_U01 (skills)** | K2MST_U11, K2MST_U24 K2MST_cm _U01 | C1-C4 | Lec 1-Lec 14, Lab 1-Lab 7 | 1-4 |
| **PEK_U02** | K2MST_U12 K2MST_U02, K2MST_cm_U02 | C4-C6 | Lab 1-Lab 7 | 2, 3, 4 |
| **PEK_U03** | K2MST_U20, K2MST_U25 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 K2MST_cm_K01 | C4-C8 | Lab 1-Lab 7 | 2, 3, 4 |
| **PEK_K02** | K2MST_K01 K2MST_cm_K02 | C1-C8 | Lec 1-Lec 14, Lab 1-Lab 7 | 1-4 |

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