**The International College of Economics and Finance**

**Syllabus for Probability Theory and Statistics, 2020-2021**

**1. Course Description**

**Pre-requisites**

None

**Abstract**

Introductory Probability Theory and Statistics is a two-semester course for first-year students of the ICEF. The course is taught in English. The main objective of the course is to provide students with knowledge of basic probability theory and statistics. By the end of the course the students should master mathematical foundations of probability theory and basic methods of statistical analysis of data. They should understand the notion of randomness and methods how to describe it using probability distributions, understand the concept of a random variable, know how to perform operations with random variables and to compute their basic characteristics (expectation, variance, covariance, etc.), understand main limit theorems. Furthermore, the students should know how to formulate and solve typical problems of basic statistics: descriptive analysis of data, point and interval parameter estimation, hypothesis testing.

**2. Learning Objectives**

The students get in the course basic knowledge and skills of statistical analysis and its application. The students should understand essential concepts of probability theory and statistics. They should also know how to build a statistical model of real natural or socio-economic phenomena, perform basic steps of statistical analysis, and make conclusions justified by available evidence from data. The methods and models should be mastered practically on real data sets with modern econometric software.

**3. Methods of instruction:** lectures, seminars, home assignments.

**4. Reading List**

**Required:**

Wonnacott R. J., Wonnacott T. H. Introductory Statistics for Business and Economics.

Newbold P., Carlson W. L., Thorne B. M. Statistics for Business and Economics.

**Optional:**

Durrett R. Elementary Probability for Applications.

Mann P. S. Introductory Statistics.

**5. Special Equipment and Software Support**

MS Excel

**6. Grading System and Examination Type**

The students sit two written examinations – a midterm examination in the end of the second module and the final examination in the end of the fourth module. The students also write a midterm test in the end of the first module. Sample materials for knowledge assessment are available in ICEF Information system at [https://icef-info.hse.ru](https://icef-info.hse.ru/). There are no blocking elements.

The formula for the course grade is

**G=0.2\*(0.35\*Goct+0.5\*Gdec+0.15\*Gha1)+0.1\*Gha+0.2\*Gmar + 0.5\*Gfin**

where Gha1 and Gha2 are the grade for home assignments in semester 1 and 2, Gfin is the grade for final exam, Goct, Gdec, Gmar are the grades for October, December, and March ICEF exam and mid-terms out of 100.

In case of a failing total grade on the 100-point scale, the lecturer has the right to give a passing total grade on the 10-point scale, if the student received a grade 45 or more for the final examination. In the case of a passing grade on the 100-point scale, the lecturer has the right to give a failing total grade on the 10-point scale, if the student received a grade 15 or less for the final examination.

The assessment of the exam paper is based on the marking scheme that comes with the exam assignment. Each problem and their sub parts are worth a certain number of points, the sum of these points is equal to 100, which is the maximum grade for the exam on the 100 point scale. The student is awarded the assigned number of points for the correct answer to each part of the question and partial credit may also be awarded.

Retake procedure

Only the December and the final examinations can be retaken. The grade for the December retake is not counted towards the final grade. If a student retakes the final examination the final grade for the course out of 100 is determined as the average of the grade for the retake and the grade for the course before the retake.

**7. Course Plan**

**1. Elements of probability theory**

1.1. An experiment with a random outcome. The notion of a random event and its probability.

1.2. Operations with random events.

1.3. The classical definition of probability. Elementary combinatorics.

1.4. Geometric probability.

1.5. Conditional probability. Independent events. The formula of total probability and Bayes’ formula.

**2. Discrete random variables**

2.1. The notion of a random variable. Distributions of discrete random variables.

2.2. Operations with random variables.

2.3. The mean value of a random variable (expectation). Variance. Standard deviation.

2.4. Joint distributions of random variables. Conditional distributions. Independent random variables.

2.5. Sequences of independent trials. Binomial distribution.

2.6. Other discrete distributions.

**3. Continuous random variables**

3.1. The notion of a continuous random variable. Distributions of continuous random variables. Cumulative distribution function and probability density function.

3.2. Mean value (expectation). Variance. Standard deviation.

3.3. The normal distribution and its properties.

3.4. Other continuous distributions.

**4. Limit theorems**

4.1. Law of Large Numbers.

4.2. Central Limit Theorem. Normal approximation of the binomial distribution.

**5. Populations and samples**

5.1. Populations and samples. Simple random sample.

5.2. Methods of data representation. Descriptive statistics. Statistical graphics.

**6. Point estimation of parameters**

6.1. The notion of a point estimate. Example: sample mean and sample variance.

6.2. Sampling distributions.

6.3. Properties of estimates. Unbiased and consistent estimates. Effective estimates.

6.4. Properties of sample mean and sample variance.

**7. Confidence intervals**

7.1. The notion of a confidence interval. One-sided and two-sided intervals.

7.2. Confidence intervals for the mean of a normal distributions. Student’s distribution.

7.3. Normal approximation for a confidence interval for the mean of a large sample. Confidence interval for proportion.

7.4. Confidence interval for the difference of two means (paired and independent samples).

7.5. Confidence interval for the variance of a normal distribution. Chi-square distribution.

7.6. Confidence interval for the ratio of two variances. F-distribution.

**8. Testing of statistical hypotheses**

8.1. The notion of a hypothesis and a statistical test. Errors of first and second type. Significance and power of test, p-values. Two-sided and one-sided tests.

8.2. Standard tests. Tests for population mean and the difference of means of independent and paired populations.

8.3. Tests for population variance and for ratio of variances of two populations.

8.4. Pearson’s chi-square test. Contingency tables.

**9. (\*) Simple linear regression**

9.1. X–Y plot. Fitting a line. Ordinary least squares.

9.2. Errors and residuals. Statistical properties of regression estimates.

9.3. Using regression to make predictions.

9.3. Confidence interval for the slope. Testing hypothesis for the slope.

**10. Planning and organizing a statistical study**

10.1. Sample surveys and statistical experiments.

10.2. Sampling methods: simple random sampling, stratified sampling, cluster sampling.

10.3. Planning and organizing an experiment. Control groups, randomization, blocked design.

10.4. Sources of bias in statistical studies.

**Distribution of hours for topics and types of work**

|  |  |  |  |
| --- | --- | --- | --- |
| No | Topic | **Contact hours** | |
| **Lectures** | **Classes** |
| 1 | Elements of Probability Theory | 4 | 4 |
| 2 | Discrete random variables | 6 | 6 |
| 3 | Continuous random variables | 6 | 6 |
| 4 | Limit theorems | 4 | 4 |
| 5 | Populations and samples | 4 | 4 |
| 6 | Point estimates | 6 | 6 |
| 7 | Confidence intervals | 10 | 10 |
| 8 | Hypothesis testing | 12 | 12 |
| 10 | Planning and organizing a statistical study | 6 | 6 |
|  | Revision | 6 | 6 |
|  | Total: | 64 | 64 |

**Learning outcomes**

|  |  |  |
| --- | --- | --- |
| **No** | **Topics titles** |  |
| **Learning outcomes** |
| 1. | Elements of Probability Theory | - Understand basic concepts of probability theory: random outcomes, random events, conditional probability, and independent random events.  - Be able to apply basic probabilistic formulas: the formula of total probability, Bayes’ formula. |
| 2. | Discrete random variables | - Understand the concept of a random variable and its distribution.  - Be able to compute the basic characteristic of random variables: expectation, variance, covariance. |
| 3. | Continuous random variables | - Understand the concept of a continuous probability distribution, and a probability density function.  - Know how to compute probabilities for continuous random variables, their expectations, variance, covariance. |
| 4. | Limit theorems | Understand and know how to apply the Law of Large Numbers and the Central Limit Theorem. |
| 5. | Populations and samples | - Understand the difference between a population an a sample.  - Be able to formalize a sampling procedure in terms of concepts of probability theory. |
| 6. | Point estimates | - Be able to compute basic point estimates of population mean and population variance.  - Understand the concepts of statistical bias, unbiased estimators and efficient estimators. |
| 7. | Confidence intervals | - Be able to construct confidence intervals for population mean, population proportion, or population variance in the case of a one-sample selection.  - Be able to construct confidence intervals for population mean, population proportion, or population variance in the case of a two-sample selection from independent populations. |
| 8. | Hypothesis testing | - Understand the concepts of a null hypothesis and an alternative hypothesis.  - Understand the concepts of type 1 and type 2 errors.  - Know how to apply the basic statistical tests for population mean and proportion variance in the cases of a one-sample study and a two-sample study. |
| 9. | Planning and organizing a statistical study | - Be able to select an appropriate sampling method in practical problems.  - Be able to organize a statistical controlled experiment.  - Understand the concepts of completely randomized design, randomized blocked design, blinding, double blinding. |
| 10. | Revision | - Revise the material studied during the year. |

**Organization of Studies for Persons with Limited Mobility and Disabilities**

If necessary, learners with limited mobility or a disability (as per his/her application), as well as per his/her individual rehabilitation programme, may be offered the following options for receiving learning information with due consideration of his/her individual psycho-physical needs (e.g., via eLearning studies or distance technologies):

*for persons with impaired vision*: enhanced fonts in hard copy documents; e-documents; audio files (transfer of study materials to an audio-format); hard copy documents with the use of Braille; individual consultation with a facilitated communicator; individual assignments and mentoring;

*for persons with hearing impairments*: in hard copy; e-documents; video materials with subtitles; individual consultation with a facilitated communicator; individual assignments and mentoring;

*for persons with a muscular-skeleton disorder*: in hard copy; e-documents; audio-files, individual assignments and mentoring.