



FACULTY OF SOCIAL SCIENCES

Applied Statistics with Network Analysis (MASNA) Program

Probability Theory Course Syllabus

Professor: TBD
Office: TBD
Office Hours: TBD
Email: TBD

Class Hours: TBD

Text & Materials

1. Required readings:

- Sheldon Ross. A first course in probability. Eighth Edition. Pearson Education, Inc.2010.
- Dimitri P. Bertsekas and John N . Tsitsiklis. Introduction to Probability. Second Edition. Athena Scientific. 2008.

2. Optional Readings:

- Grimmett G.R., Stirzaker D.R. One thousand exercises in probability. Oxford University Press. 2003.
- Shiryaev A.N. Probability – 1. Springer-Verlag New York. 2016.

I. Course Summary, overview and objectives

This course will take a modern, data-analytic approach to the multiple regression model. Our coverage of the material will emphasize the ways that graphical tools can augment traditional methods for describing how the conditional distribution of a dependent variable changes along with the values of one or more independent variables. The course will examine the basic nature and assumptions of the linear regression model, diagnostic tools for detecting violations of the regression assumptions, and strategies for dealing with situations in which the basic assumptions are violated.

The goal of the course is ensure that students understand topics and principles of applied linear models on an advanced level. Therefore, the course is designed to provide:

1. New insights about regression analysis;
2. a general overview of various modern extensions to the traditional linear model;
and
3. innovative, effective methods for presenting the results from statistical investigations of empirical data.

Specific topics to be covered include: data visualization and transformation; assumptions of the linear model; regression diagnostics and model assessment; robust and resistant regression; weighted least squares; generalized linear models, resampling methods; nonlinear regression; nonparametric regression; generalized additive models; and graphical regression.

The Course develops the following competencies

Competencies	NC/NRU-HSE Code	Descriptors - the learning outcomes (the indicators of achievement)	Teaching forms and methods of that contribute to the development of a competence
<u>Systemic Competencies</u>			
1. Ability to improve and develop their intellectual and cultural level, build a trajectory of professional development and career.	CK-4	Can improve and develop their intellectual and cultural level, build a trajectory of professional development and career based on knowledge they get at the course.	Lectures, readings, in-class exercises, data analysis projects
2. Ability to analyze, verify, evaluate the completeness of information in the process of their professional activities, to replenish and synthesize missing information, if necessary.	CK-6	Able to analyze, verify, evaluate the completeness of information, can integrate information found from various sources and compensate for lack of data by adjusting models.	Lectures; independent work.
<u>Social and Personal Competencies</u>			
3. Ability to generate fundamentally new ideas and products, to hold creativity and initiative.	ПК-8	Can effectively generate new ideas and products in their professional activities.	Lectures, readings, in-class exercises, data analysis projects
<u>Instrumental Competencies</u>			
4. Ability to analyze and reproduce the meaning of interdisciplinary texts using the language and apparatus of applied mathematics.	ПК-10	Can understand and concisely reproduce the interdisciplinary texts with the usage of language and apparatus of applied mathematics.	Lectures, readings, in-class exercises, data analysis projects
5. Ability to build and solve mathematical models in accordance with the profile of training and specialization.	ПК-17	Can build and solve mathematical models without direct supervision, and is capable of using these methods to analyze complex models.	Lectures, readings, in-class exercises, data analysis projects

Competencies	NC/NRU-HSE Code	Descriptors - the learning outcomes (the indicators of achievement)	Teaching forms and methods of that contribute to the development of a competence
6. Able to understand and apply modern mathematical tools in research and applied activities.	ПК-18	Can effectively apply different modern mathematical tools in research and applied activities.	Lectures, readings, in-class exercises, data analysis projects
7. Ability to apply modern programming and data manipulation languages, operating systems, electronic libraries and software packages, network technologies, etc. in research and applied activities.	ПК-20	Is capable to apply modern programming and data manipulation languages, operating systems, electronic libraries and software packages, network technologies, etc. in research and applied projects.	Lectures, readings, in-class exercises, data analysis projects

II. Teaching components

This course will emphasize advance preparation for each class period and will involve a high level of class participation. Often, experiential exercises and simulations will be used to illustrate key network analysis concepts. While I do not take attendance, missing classes on a regular basis will be detrimental to your learning.

Teaching Format

This is an interactive, participatory course. The course will be run mainly as a combination of lectures, small group discussions, and in-class exercises. In order to have good discussions of the course materials, students must come prepared for class. This means having **read the assigned reading materials before class and coming prepared to discuss the readings and ask questions.**

Lectures

Lectures are an integral part of this course, and they consist of two parts: the material I present in class and a slide deck with many more details (which we do not have time to go over in class). The slide deck, in many cases, is almost sufficient for you to master the material. In other words, if you read and understand *everything* in the slide deck, the assigned reading will only solidify the material further, but may not be required to do well in class. If you have issues with what is written in the slide deck, then the assigned reading material is essential – you must read and go through every minute detail, or you are highly unlikely to succeed.

III. Requirements and Evaluation Criteria

Grades

Course grades will be computed as follows:

Course Element	% Towards Final Grade
Final Exam	30%
<i>Final In-Class and/or Take-home exam (at the discretion of the instructor)</i>	30%
Participation and responsibility grade	70%
<i>Class participation</i>	10%
<i>3 home assignments, each assignments x 20%</i>	60%
<i>each</i>	10%
Extra credit	As assigned
Total	100%

Grading Scale, Rounding, and Curves:

Your grade is the grade you *earn*. There is no curve imposed in this class.

I prefer to hear your concerns about grading during the semester. **Do not wait until the end of the semester to see me regarding problems with course materials or your performance (it will be too late to address deficiencies at the end of the semester).** If you are aware that you must achieve a particular grade in this course, please see me during the first week of the course. This will allow me to alert you of deficiencies in your performance. There is nothing that either of us can do at the end of the course.

Extra-credit: I firmly believe that education does not start and end with the required course material. Very often, what you remember the most from the course does not come from a book, but perhaps from a wise comment by a peer, a clever exercise, or an article you've read in Wall Street Journal because you related it to the course you were taking, but would have missed otherwise. I encourage students to learn things outside of class. I will sometimes point you to the facts or readings that I find interesting, and may ask you to write a page or two, or lead a discussion on such a topic. Because these topics often come up after the grading system has been announced and we are well into the semester, I will assign extra-credit points to them. A few things need to be noted:

- You *do not need* extra credit to do well in this class. Please do not feel obligated to turn in extra-credit assignments you are not interested in doing.
- Extra-credit assignments are due on their due date, and cannot be made up for ANY reason (including university-approved absences).
- DO NOT ask me for extra-credit assignments at the end of the semester if you are a few points short of your desired grade. Take care of any potential shortfalls when the opportunities are provided.

- Extra-credit opportunities will be offered to everyone. No individual extra-credit assignments will be offered or provided for any reason.

Homeworks

In this class, homeworks are essential for learning. Simply put, you CANNOT learn statistics by simply attending the class. Homework assignments are handed out in class (during seminars) and will be available electronically. I strongly recommend that you do not wait until the due date to complete those, and work on the problems a few at a time throughout the assigned period.

Due dates for all homeworks are clearly stated in the syllabus. Late homeworks are not accepted for ANY REASON.

Rounding and grade calculation

Your final grade is an average of a cumulative grade and a final exam grade. Grades earned as percentages will translate into point grades in 10% increments: 10% - 1 point. 20% - 2 points, etc. Grades will be assigned as whole grades only. Grade rounding follows the standard mathematical averaging rules: 34.9% is a 3: 34.99999% is a 3, and only 35.0% is a 4. I know 1/10 of a percent is not a big deal, but please do not ask me to “bump” your grade 1/10 of a percent; earn it instead.

IV. Tips for Success and Other Issues of Concern

Absences and Excuses

You are responsible for attending class. If you miss class, you are still responsible for everything covered in class, including announcements. Absences excuse you (the body) NOT ANY WORK THAT IS DUE, *even if excuse is documented*. Failure to turn in assignments on time will result in a loss of participation/responsibility points, and a zero on the assignment. Similarly, being absent does not excuse you from obtaining handouts and assignments that you may have missed. It is your responsibility to find out what you have missed and to make arrangements to obtain any handouts, assignments, etc. All work is due as stated in the course schedule. **Exception: religious observance absences as stated below.**

Religious Observance: In keeping with university policy, accommodations will be made for observance of religious holidays. I require that you request accommodations in advance by notifying me in writing.

Class preparation

Considering that class preparation is a personal matter, and that there is no one formula, the following are some generally recommended guidelines for most cases:

1. Read the assigned material quickly, noting the major issues and a general sense of the layout. Read to get a sense of what the chapter is about. Ask yourself how you can relate to the materials covered, and whether all the new terms make sense.
2. Reread the material carefully, annotating, highlighting and distinguishing important information, omissions, and questions raised by the reading.

3. Decide what the most important issues are. Write down questions you don't understand.
4. Discuss the chapter with others, before class if possible, to test out your ideas and further your understanding of the issues.
5. Prepare notes to guide your class participation, including: answering assigned questions, summary of the main issue(s), further questions raised by the reading, assumptions made by the chapter, your personal experiences, and possible approaches or solutions to any problems assigned with the chapter.
6. DO YOUR HOMEWORK and ATTEND SEMINARS TO COMPLETE LABS.

Virtual Office Hours – LMS Forum

This is a very large class, and I may not be able to answer all questions that are e-mailed to me on a timely basis. Moreover, I've found over the years that usually 90% of all questions from students are nearly identical – that is, if you do not understand something, chances are, most other people do not, either. Instead of repeating answers over and over via email, I will be answering all content-related questions in LMS forum (it is already open for the class, please feel free to start threads and ask questions).

Feel free to answer questions posted on the Forum. Not only that will provide an answer to your peers quicker (I may not be able to respond to Forum questions immediately), but I will also monitor your Forum activities and will provide **extra-credit** to the most active students who provide best answers.

Messages and Memos for Me

If you have any messages or specific requests for me, please submit them by e-mail or in typed format. Ensure that your message includes your name, a complete description of your concern, and a recommendation for resolution. Please note that I have a very busy inbox; usually, I answer emails only once a day, very early in the morning. So if you send me a question around 10 am, please do not expect to receive answer until the following day.

Stay Informed about Class Schedules & Policies

It is the student's responsibility to stay informed about class schedules and policies. The information you need is included on both the paper copy of the syllabus, and the online website pages. In addition, announcements will be made regularly in class and on website, and it is your responsibility to keep up with that information. If you are unclear about any policies or other information, please ask promptly. Don't wait and get an unpleasant surprise later.

Participation Ground Rules

In an effort to provide a classroom environment as conducive to learning as possible, the following ground rules should be observed:

1. *Confidentiality.* Concepts and ideas can be taken from the class and discussed freely. However, personal stories or issues raised by individuals are to be kept confidential and as the property of the class.
2. *Respectful Listening.* When differing with another participant's point of view, listen first before raising questions. When another participant raises a point we disagree with or find offensive, it is important to remember that the human being behind that question or

comment deserves respect. Please freely utilize the concepts we'll learn in the second week of class.

3. *Participation*. Participants who tend to be quieter are encouraged to contribute to enhancing the learning process by sharing their perspectives and experiences. Those who are aware they are prone to monopolizing discussions are encouraged to self-monitor their behavior and make room for quieter students.
4. *No Zaps*. In keeping with the notion of respectful listening, "putting-down" others in class is discouraged. "Zapping" another person often serves to discourage open and honest exchange of ideas among the whole group.

Academic Honesty

Scholastic dishonesty, including cheating in exams or plagiarism, will be treated as a violation of university's regulations. As commonly defined, plagiarism consists of passing off as one's own the ideas, words, writings, etc., which belong to another. In accordance with this definition, you are committing plagiarism if you copy the work of another person and turn it in as your own, even if you should have the permission of that person. Plagiarism is one of the most severe forms of academic dishonesty and can be expected to result in appropriate consequences.

You must complete exams and assignments alone, except group exercises. You may use only the materials I specify to help you complete your work. If, due to a disability or extraordinary circumstances, you need special accommodations or help in completing course requirements, you must see the instructor BEFORE the exam or assignment due date. Personally, I have no tolerance for cheating, regardless of the reason. **Simply put, don't do it.**

Copyright Notice

All handouts in this course are copyrighted, including all materials posted on the website for this course. "Handouts" refers to all materials generated for this class, which include but are not limited to the syllabus, class notes, quizzes, exams, lab problems, in-class materials, review sheets, and additional problem sets. You have the right to download materials from the course website for your own use during this class; however, because these materials are copyrighted, you do not have the right to copy the handouts for other purposes unless the instructor expressly grants permission.

Good luck and have fun!

V. Course Content

The topics to be covered in course, with assigned readings and corresponding assignments, are listed below. They are subject to change with notice, and topics may not always be given in the order listed. Also, some topics might require more than one class to go over. Therefore, please see the class schedule provided in the separate document for the exact schedule or consult the instructor.

1. **Axioms of Probability** (Ch.2 in [1] and Ch.1 in [2])
Sample space and events. Axioms of probability. Classical probability: finite sample spaces having equally likely outcomes. Probability as a continuous event function. Probability as a measure of belief
2. **Conditional Probability and Independence** (Ch.3 in [1] and Ch.1 in [2])

- Conditional probabilities. The multiplication rule. Formula of total probability. Bayes's formula. Independent events. Bernstein example. $P(\cdot|F)$ is a probability.
3. **Discrete Random Variables** (Ch.4 in [1] and Ch.2 (except Sect. 2.5-2.7) in [2])
Random variables. Discrete random variables. Expected value. Expectation of a function of a random variable. The Bernoulli and binomial random variables. The Poisson random variable. Other discrete probability distributions. Expected value of sums of random variables. Properties of the cumulative distribution function. Generation functions for positive integer-valued random variables. Branching processes. The probability of ultimate extinction for branching processes.
 4. **Continuous Random Variables** (Ch.5 in [1] and Ch.3 (except Sect. 3.4-3.6) in [2])
Probability density function. Expectation and variance of continuous random variables. The uniform random variable. Normal random variables. Exponential random variables. Other continuous distributions. The distribution of a function of a random variable.
 5. **Jointly Distributed Random Variables** (Ch.6 (except Sections 6.6 and 6.8) in [1] and Ch.3 (Sections 3.4-3.6) in [2])
Joint distribution functions. Independent random variables. Sums of independent random variables. Conditional distributions: discrete case and continuous case. Joint probability distribution of functions of random variables
 6. **Properties of Expectation** (Ch.7 in [1] and Ch.4 in [2])
Covariance, variance of sums. Correlations. Conditional expectation. Conditional expectation and prediction. The continuous Bayes' rule.
 7. **Limit Theorems** (Ch.8 in [1] and Ch.5 in [2])
Chebyshev's inequality and the weak law of large numbers. The central limit theorem. The strong law of large numbers. Monte-Carlo method. Other inequalities. Bounding the error probability when approximating a sum of independent Bernoulli random variables by a Poisson random variable
 8. **Additional Topics in Probability** (Ch.9, Sections 9.2-9.4 in [1] and Ch.7 in [2])
Discrete-Time Markov Chains. Classification of States. Steady-State Behavior. Uncertainty and entropy.