

# **STA 321 –Topics in Advanced Statistics**

Fall 2024

## **CONTACT INFORMATION**

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**Office:** UNA107

**Office Hours:** Monday 3:00 PM – 5:00 PM

Tuesday 11:00 PM – 12:00 PM

Thursday 2:00 PM – 5:00 PM

**Course Webpage:** <https://pengdsci.github.io/sta321/>

## **COURSE DESCRIPTION**

The course will cover select topics in categorical analysis, non-parametric, and time series analysis. Emphasis will be placed on statistical programming, particularly simulations.

Prerequisites: STA 321 requires prerequisites of C or better in STA 311, STA 319, STA 320, and MAT 421.

## **COURSE LEARNING OUTCOMES**

After finishing this course, students will be able to

1. use appropriate statistical methods and models to address real-world problems.
2. use a statistical programming language to perform rigorous data analysis.
3. correctly utilize data and identify sources of bias and misinterpretations.
4. use a software program to prepare formal statistical reports.
5. communicate statistical results effectively with both technical and non-technical audiences with appropriate visual aids.

## **MEETING & ASSESSING STUDENT LEARNING OUTCOMES**

Course projects will be used to assess students' learning outcomes. The detailed evaluation components are listed in the next section of grading and evaluation.

## EVALUATION & GRADING

The course grade will be determined by the following components:

(1). Four mini-projects on data analysis (4 mini-projects, 15% each, total 60%)

Mini-project #1: bootstrap linear regression

Mini-project #2: Binary logistic regression

Mini-project #3: Regression with counts and rates

Mini-project #4: Time series – exponential smoothing

(2). Weekly data analysis assignments ( 30%)

(3). Attendance and participation (10%).

A letter grade will be assigned based on performance in the course according to the following scale:

Grade	Quality Points	Percentage Equivalents	Interpretation
A	4.00	93-100	Excellent
A-	3.67	90-92	
B+	3.33	87-89	Superior
B	3.00	83-86	
B-	2.67	80-82	
C+	2.33	77-79	Average
C	2.00	73-76	
C-	1.67	70-72	
D+	1.33	67-69	Below Average
D	1.00	63-66	
D-	0.67	60-62	
F	0	< 60%	Failure

Refer to the Undergraduate Catalog for a description of NG (No Grade), W, Z, and other grades.

## ATTENDANCE AND PARTICIPATION POLICY

I take attendance. More than two absences will affect your final grade by 2% per absence, with a maximum penalty of 10%. If you know that you will be absent due to illness or a family emergency (need a document), please let me know via email.

I measure class participation based on the following criteria:

- arriving to class on time;
- paying attention during short lectures;
- respectful listening when I or your peers are speaking;
- your ability to be fully engaged in your learning without texting, checking your phone or email, or participating in other digital distractions;

If you are unable to meet the above criteria, I will take away participation points throughout the semester. Keep in mind you start the semester with ALL your points, so don't lose them!

## MAJOR REFERENCES

This is an advanced topics class. The topics to be covered are taken from different texts. I will not assign a required textbook for this class. Instead, I provide a list of eBooks that are freely available in WCU's library in the following.

1. [Introduction to Computer-Intensive Methods of Data Analysis in Biology](#)
2. [Applied Regression and Modeling: A Computer-integrated Approach](#)
3. [Modern Regression Techniques Using R: A Practical Guide](#)
4. [Regression Analysis with R](#): Design and Develop Statistical Nodes to Identify Unique Relationships Within Data at Scale
5. [Regression Models for Categorical, Count, and Related Variables: Applied Approach](#), by John Hoffmann, the University of California Press, 2016.
6. [Practical Time Series Analysis](#)

## TENTATIVE TOPICS

Following is the list of tentative topics to be covered in the semester. I may modify the list as we move forward during the semester. The course web page will provide an up-to-date list of topics every week.

### **Week 1:** Setting up computing tools - getting started with R, RStudio, and R Markdown

1. Introduction: class structure, topics, assessments, and logistics.
2. Install R, RStudio, and possibly MikTeX
3. Create R Markdown document- Knit HTML, PDF, and WORD file
4. Getting started with R: basic operations, vectors, data frames (R data sets).
5. Install and load R libraries
6. GitHub repository

### **Week 2:** Nonparametric Bootstrap Inferences

1. Review of simple random sampling (SRS) plan
2. Sampling from empirical distribution – Bootstrap sampling
3. Bootstrap confidence intervals
4. **R Applications:** Case study – CI and testing about population means

### **Week 3: Review:** Correlation and Simple Linear Regression

1. Relationship between two numerical variables
2. Linear relationship: the strength of linear correlation -coefficient of correlation
3. Least square regression model – structure, assumptions, and interpretation
4. Diagnostics, R square, and interpretation

5. **R Applications:** Case study - simple linear regression (SLR) with R.

**Week 4:** Multiple Regression

1. Turn categorical predictor variables into dummy variables
2. Assumptions, Goodness-of-fit measures, and diagnostics
3. Variable selection methods
4. Summarizing output and interpreting coefficients and R square
5. **R Applications:** Case study - MLR with R

**Week 5:** Nonparametric Bootstrapping Regression Modeling

1. Bootstrapping records
2. Bootstrapping residuals
3. Bootstrap confidence intervals of regression coefficients
4. Bootstrapping test for regression coefficients
5. **R Applications:** Case study – Bootstrapping regression modeling

**Week 6:** Categorical Regression – Simple Logistic Regression

1. Practical question and model formulation
2. Structure of the model
3. Interpretation of the regression coefficients
4. **R Applications:** Case study – fitting logistic regression with R

**Week 7:** Categorical Regression – Multiple Logistic Regression

1. Models with only categorical predictor variables – Dummy variable
2. Interpretation of coefficients
3. Variable selection methods and criteria
4. **R Applications:** Case study - logistic regression with R

**Week 8:** Predictive Modeling with Logistic Regression

1. Measures of prediction performance
2. Confusion matrix and predictive errors
3. Cross-validation and ROC curve

**Week 9:** Frequency Regression - Simple Poisson Regression

1. Practical question and model formulation
2. Model structure and interpretation
3. Regression on rates
4. **R Applications:** Case-study - fitting counts and rates in biology

**Week 10:** Dispersed Poisson Regression Modeling

1. Poisson regression with more than one predictor variable
2. Categorical predictor variable – dummy variables must be defined
3. Issues of overdispersion and underdispersion
4. Quasi-Poisson models

**Week 11: Concepts of Time Series**

1. The nature of time series data – Dependency between observations
2. The purpose of time series – forecasting
3. Autocorrelation and moving average
4. Measures of goodness-of-forecasting
5. Types and approaches to time series modeling
6. **R Applications:** Illustrative examples of time series using R

**Week 12: Moving Average and LOESS Smoothing**

1. Decompose a time series: trend, seasonality, and random error.
2. Additive and multiplicative models
3. The moving average (MA) and double MA models
4. LOESS smoothing model: fitting, forecasting, and evaluating
5. **R Applications:** Case study – LOESS smoothing and forecasting

**Week 13: Exponential Smoothing Models**

1. Single exponential smoothing models
2. Holt's trend models
3. Holt-Winters' seasonal models
4. Model selection – measures of accuracy.
5. **R Applications:** Case-study – examples of exponential smoothing.
- 6.

**Week 14: Preparing project presentation**

1. The types of models: Linear models, GLM, and time series models (smoothing)
2. Choose one of the three projects to present to the class
3. [Submit a PPT presentation by the end of Friday via D2L.](#)
4. Each presentation allows 15 minutes: 10 minutes for presenting and 5 minutes for QA.

**UNIVERSITY POLICIES, RESOURCES, AND SUPPORTS****ACADEMIC & PERSONAL INTEGRITY**

It is the responsibility of each student to adhere to the university's standards for academic integrity. Violations of academic integrity include any act that violates the rights of another student in academic work, that involves misrepresentation of your own work, or that disrupts the instruction of the course. Other violations include (but are not limited to): cheating on assignments or examinations; and plagiarizing, which means copying any part of another's work and/or using ideas of another and presenting them as one's own without giving proper credit to the source; selling, purchasing, or exchanging of term papers; falsifying of information; and using your own work from one class to fulfill the assignment for another class without significant modification. Proof of academic misconduct can

result in the automatic failure and removal from this course. For questions regarding Academic Integrity, the No-Grade Policy, Sexual Harassment, or the Student Code of Conduct, students are encouraged to refer to the Department Undergraduate Handbook, the [Undergraduate Catalog](#), the [Ram's Eye View](#), and the [University website](#).

### ACCOMMODATIONS FOR STUDENTS WITH DISABILITIES

West Chester University is committed to providing equitable access to the full WCU experience for Golden Rams of all abilities. Students should contact the [Office of Educational Accessibility \(OEA\)](#) to establish accommodations if they have had accommodations in the past or if they believe they may be eligible for accommodations due to a disability, whether or not it may be readily apparent. There is no deadline for disclosing to OEA or for requesting to use approved accommodations in a given course. However, accommodations can only be applied to future assignments or exams; that is, they can't be applied retroactively. Please share your letter from OEA as soon as possible so that we can discuss accommodations. If you have concerns related to disability discrimination, please contact the university's ADA Coordinator in the [Office of Diversity, Equity, and Inclusion](#) or 610-436-2433.

### UNIVERSITY-EXCUSED ABSENCES POLICY

Students are advised to carefully read and comply with the University-Excused Absences Policy, including absences for university-sanctioned events, contained in the WCU Undergraduate Catalog. In particular, please note that the "responsibility for meeting academic requirements rests with the student," that this policy does not excuse students from completing required academic work, and that professors can require a "fair alternative" to attendance on those days that students must be absent from class in order to participate in a University-Sanctioned Event.

### REPORTING INCIDENTS OF SEXUAL VIOLENCE

West Chester University and its faculty are committed to assuring a safe and productive educational environment for all students. In order to comply with the requirements of Title IX of the Education Amendments of 1972 and the University's commitment to offering supportive measures in accordance with the new regulations issued under Title IX, the University requires faculty members to report incidents of sexual violence shared by students to the University's Title IX Coordinator. The only exceptions to the faculty member's reporting obligation are when incidents of sexual violence are communicated by a student during a classroom discussion, in a writing assignment for a class, or as part of a University-approved research project. **Faculty members are obligated to report sexual violence or any other abuse of a student who was, or is, a child (a person under 18 years of age) when the abuse allegedly occurred to the person designated in the University Protection of Minors Policy.** Information regarding the reporting of sexual violence and the resources that are available to victims of sexual violence is set forth on the [WCUPA Sexual Misconduct website](#).

### INCLUSIVE LEARNING ENVIRONMENT AND ANTI-RACIST STATEMENT

Diversity, equity, and inclusion are central to West Chester University's mission as reflected in our [Mission Statement](#), [Values Statement](#), [Vision Statement](#), and [Strategic Plan: Pathways to Student Success](#). We disavow racism and all actions that silence, threaten, or degrade historically marginalized groups in the U.S. We acknowledge that all members of this learning community may experience harm

stemming from forms of oppression including but not limited to classism, ableism, heterosexism, sexism, Islamophobia, anti-Semitism, and xenophobia, and recognize that these forms of oppression are compounded by racism.

Our core commitment as an institution of higher education shapes our expectation for behavior within this learning community, which represents diverse individual beliefs, backgrounds, and experiences. Courteous and respectful behavior, interactions, and responses are expected from all members of the University. We must work together to make this a safe and productive learning environment for everyone. Part of this work is recognizing how race and other aspects of who we are shape our beliefs and our experiences as individuals. It is not enough to condemn acts of racism. For real, sustainable change, we must stand together as a diverse coalition against racism and oppression of any form, anywhere, at any time.

Resources for education and action are available through WCU's [Office for Diversity, Equity, and Inclusion](#) (ODEI), DEI committees within departments or colleges, the [student ombudsperson](#), and centers on campus committed to doing this work (e.g., [Dowdy Multicultural Center](#), [Center for Women and Gender Equity](#), and the [Center for Trans and Queer Advocacy](#)).

Guidance on how to report incidents of discrimination and harassment is available at the University's [Office of Diversity, Equity, and Inclusion](#).

### **EMERGENCY PREPAREDNESS**

All students are encouraged to sign up for the University's free [WCU ALERT service](#), which delivers official WCU emergency text messages directly to your cell phone. To report an emergency, call the Department of Public Safety at 610-436-3311.

### **ELECTRONIC MAIL POLICY**

It is expected that faculty, staff, and students activate and maintain regular access to university-provided e-mail accounts. Official university communications, including those from your instructor, will be sent through your university e-mail account. You are responsible for accessing that mail to be sure to obtain official University communications. Failure to access will not exempt individuals from the responsibilities associated with this course.