MA206 AY27-1

Probability and Statistics Syllabus

Course Overview

This course is an introduction to probability and statistics, following Devore (9th ed.). It develops descriptive statistics; probability; discrete and continuous random variables and their distributions; statistical inference (confidence intervals and hypothesis tests); and regression and the analysis of variance. Throughout the course you will carry out a statistical investigation on real Army-unit data hosted in the Vantage enterprise and communicate your results to a general audience.

Each lesson objective below is mapped to one or more of the seven course **Student Learning Outcomes (SLOs)** and is keyed to the relevant Devore section. Objectives reflect what is assessed on the WPRs, the Term End Exam (TEE), and the course project, and use the terminology of the Devore text.

Student Learning Outcomes (SLOs)

#	Student Learning Outcome
1	Use the investigative process in statistics to answer research questions of interest and communicate results to general audiences.
2	Produce and interpret graphical displays and numerical summaries of data.
3	Recognize and explain the central role of variability and randomness in designing studies and drawing conclusions.
4	Employ appropriate single and multivariate statistical models and interpret standard output of statistical software packages.
5	Understand and use basic ideas of statistical inference (hypothesis tests and confidence intervals) in a variety of settings.
6	Be critical consumers of statistically based results and recognize whether reported results reasonably follow from the study and analysis conducted.
7	Understand fundamentals of probability: axioms, probability of events, conditional probability and Bayes' Theorem, and modeling with distributions.

Block I: Descriptive Statistics and Probability

Table 1: Block I lesson objectives and SLO mapping

LSN	Topic	Lesson Objective	Read	WebAssign
1	Types of Data & Study Design	• Distinguish populations, samples, and processes; contrast descriptive and inferential statistics; and distinguish a statistic from a parameter. (SLO 3) • Classify data as categorical or numerical, and numerical data as discrete or continuous. (SLO 2) • Construct and interpret histograms, and describe distribution shape. (SLO 2) • Describe data-collection methods, including simple random sampling and observational versus experimental studies. (SLO 3)	1.1 1.2 S1	1.1: 003, 005, 006, 007, 008, 009 1.2: 012, 022
2	Measures of Location & Variability	• Compute and interpret the sample mean, median, and trimmed mean, and their sensitivity to outliers. (SLO 2) • Compute and interpret the sample variance, standard deviation, range, and fourth spread (IQR). (SLO 2) • Construct and interpret boxplots and comparative boxplots, and identify outliers. (SLO 2)	1.3 1.4 S2	1.3: 033, 035, 037, 039, 041 1.4: 044, 046, 049, 050, 057
3	Set Theory	• Define an experiment, its sample space, and events. (SLO 7) • Form unions, intersections, and complements of events using set operations and Venn diagrams. (SLO 7) • Represent compound events for a given experiment. (SLO 7)	2.1	2.1: 001, 005, 006, 008, 009
4	Probability Basics	• State and apply the axioms and basic properties of probability. (SLO 7) • Apply the addition rule, including its extension to three events. (SLO 7) • Compute probabilities of events using equally likely outcomes and complements. (SLO 7)	2.2	2.2: 011, 012, 014, 018, 020, 028
5	Counting	• Apply the product rule, permutations, and combinations to count outcomes. (SLO 7) • Use counting techniques to compute probabilities of equally likely outcomes. (SLO 7)	2.3	2.3: 030, 034, 035, 036
6	Conditional Probability	• Compute conditional probabilities and apply the multiplication rule. (SLO 7) • Apply the Law of Total Probability. (SLO 7) • Apply Bayes' Theorem to update probabilities given new information. (SLO 7)	2.4	2.4: 046, 048, 050, 060, 062
7	Independence	• Define independent events and use independence to simplify probability calculations. (SLO 7) • Combine counting techniques with independence. (SLO 7)	2.5	2.5: 071, 073, 074, 077, 079, 080, 088
8	Discrete Random Variables	• Define a random variable and construct the probability mass function (pmf) and cumulative distribution function (cdf) of a discrete RV. (SLO 7) • Compute the expected value $E(X)$ and variance $V(X)$ of a discrete random variable. (SLO 7) • Apply the rules of expected value and variance, including $E[h(X)]$, $E(aX+b)$, and $V(aX+b)$. (SLO 7)	3.1 3.2 3.3	3.1: 002, 004, 005 3.2: 013, 014, 016 3.3: 029

LSN	Topic	Lesson Objective	Read	WebAssign
9	Binomial Distribution	• Identify a binomial experiment and verify its conditions. (SLO 7) • Compute binomial probabilities using the pmf and cdf (tables and software). (SLO 7, 4) • State and interpret the mean and variance of a binomial random variable. (SLO 7)	3.4	3.4: 046, 047, 049, 051
10	Poisson Distribution	• Identify settings modeled by the Poisson distribution, including the Poisson process. (SLO 7) • Compute Poisson probabilities using $\mu = \lambda t$ and interpret μ. (SLO 7) • State and interpret the mean and variance of a Poisson random variable, noting that both equal μ. (SLO 7)	3.6	3.6: 080, 082, 083, 087, 088
11	Continuous Random Variables	• Use a probability density function (pdf) to compute probabilities as areas, and recognize that any exact value has probability zero. (SLO 7) • Obtain the cdf from the pdf and use it to find probabilities and percentiles. (SLO 7) • Compute the expected value, variance, and standard deviation of a continuous random variable. (SLO 7)	4.1 4.2	4.1: 002, 005 4.2: 011
12	Normal Distribution	• Identify the normal and standard normal (z) distributions. (SLO 7) • Standardize values with $z = (x - \mu)/\sigma$ and compute probabilities using the z table. (SLO 7) • Determine percentiles and z critical values for the normal distribution. (SLO 7)	4.3	4.3: 028, 034, 038
13	Exponential Distribution	• Identify the exponential distribution and relate its parameter λ to the mean and standard deviation (both $1/\lambda$). (SLO 7) • Compute exponential probabilities using the pdf and cdf. (SLO 7) • Apply the memoryless property of the exponential distribution. (SLO 7)	4.4	4.4: 059, 061
14	Exploratory Data Analysis (EDA)	• Summarize project data with appropriate graphical and numerical descriptive methods (histograms, boxplots, scatterplots). (SLO 2) • Compute and interpret the sample correlation coefficient r. (SLO 2) • Distinguish correlation from causation. (SLO 6) • Communicate exploratory findings and pose questions for further analysis. (SLO 1)	S3	—
15	Cadet-Led Review	Review Lessons 1-13.		—
16	**WPR I**	Covers concepts from Lessons 1-13.		—

Block II: Statistical Inference

Table 2: Block II lesson objectives and SLO mapping

LSN	Topic	Lesson Objective	Read	WebAssign
17	Course Lecture Drop	No class in support of the course lecture.		—
18	Central Limit Theorem	• Describe the sampling distribution of a statistic, including the sample mean $\bar{X}$. (SLO 3) • State and apply the Central Limit Theorem to approximate the distribution of $\bar{X}$ and compute probabilities for $\bar{X}$. (SLO 5) • Apply the large-sample normal approximation to the sample proportion $\hat{p} = X/n$. (SLO 5)	5.3 5.4	5.4: 046, 047, 048, 049, 050, 052
19	Confidence Intervals I	• Interpret a confidence level and the basic properties of a confidence interval. (SLO 5) • Construct a large-sample confidence interval for a population mean. (SLO 5) • Construct a large-sample confidence interval for a population proportion. (SLO 5)	7.1 7.2	7.1: 001, 007 7.2: 013, 015
20	Confidence Intervals II	• Construct a confidence interval for a mean based on a normal population using the t distribution. (SLO 5) • Determine the sample size needed to achieve a specified interval width. (SLO 5) • Interpret a confidence interval correctly. (SLO 6)	7.3	7.3: 028, 030, 033, 034
21	Intro to Hypothesis Testing	• State null and alternative hypotheses and identify the test statistic and rejection region. (SLO 5) • Carry out a z test for a population mean and compute and interpret the P-value. (SLO 5) • Define Type I and Type II errors and describe how the Type II error probability (β) depends on the true parameter value and sample size. (SLO 6) • Interpret a non-significant result: failing to reject H_0 does not prove H_0 is true. (SLO 6)	8.1 8.2	8.1: 004, 005, 006, 008 8.2: 016
22	One-Sample t-Test	• State and check the assumptions of the one-sample t test. (SLO 5) • Carry out a one-sample t test for a population mean. (SLO 5) • Relate the test conclusion to the corresponding confidence interval: a two-sided test rejects at level α exactly when the null value lies outside the $1-\alpha$ interval, and the null value falls on an endpoint when $P = \alpha$. (SLO 5, 6)	8.3	8.3: 029, 031, 033, 036
23	One-Proportion z-Test	• Check the large-sample conditions for inference on a proportion. (SLO 5) • Carry out a large-sample z test for a population proportion. (SLO 5) • Distinguish statistical significance from practical significance. (SLO 6)	8.4 8.5	8.4: 042, 044, 048, 050

LSN	Topic	Lesson Objective	Read	WebAssign
24	Two-Sample t-Test	• Distinguish independent-sample from paired designs. (SLO 3) • State and check the assumptions of the two-sample t test. (SLO 5) • Carry out the two-sample t test for $\mu_1 - \mu_2$ using the approximate degrees of freedom. (SLO 5) • Construct and interpret a confidence interval for $\mu_1 - \mu_2$. (SLO 5) • Interpret two-sample t-test output from statistical software and draw a conclusion in context. (SLO 4, 5, 1) • Translate a directional research claim into the correct one-sided alternative. (SLO 5, 6)	9.2	9.2: 019, 020, 021, 024, 031
25	Paired t-Test	• Identify paired data and the appropriate paired design. (SLO 3) • State and check the assumptions of the paired t test. (SLO 5) • Carry out the paired t test for a mean difference. (SLO 5) • Construct and interpret a confidence interval for a mean difference. (SLO 5) • Explain how pairing reduces the standard error relative to an independent two-sample analysis. (SLO 3, 5)	9.3	9.3: 037, 039, 041, 044
26	Two-Proportion z-Test	• Check the large-sample conditions for inferences about $p_1 - p_2$. (SLO 5) • Carry out a large-sample z test for a difference between two population proportions. (SLO 5) • Construct and interpret a confidence interval for $p_1 - p_2$. (SLO 5)	9.4	9.4: 050, 056, 057
27	Cadet-Led Review	Review Lessons 18-26.		—
28	**WPR II**	Covers concepts from Lessons 18-26.		—

Block III: Regression and the Analysis of Variance

Table 3: Block III lesson objectives and SLO mapping

LSN	Topic	Lesson Objective	Read	WebAssign
29	Simple Linear Regression I	• State the simple linear regression model $Y = \beta_0 + \beta_1 x + \varepsilon$ and its assumptions. (SLO 4) • Estimate β_0 and β_1 by least squares and interpret the estimated regression line. (SLO 4)	12.1 12.2	12.1: 002, 003, 008, 009 12.2: 013, 014
30	Simple Linear Regression II	• Carry out a t test for the slope β_1 and construct a confidence interval for β_1. (SLO 5) • Compute and interpret the sample correlation r and the coefficient of determination r^2 (from SSE and SST). (SLO 2, 4) • Fit a simple linear regression in R and interpret the standard software output: estimated coefficients, standard errors, t statistics and P-values, and r^2. (SLO 4)	12.2 12.3 12.5	12.2: 016 12.3: 031, 034, 036 12.5: 057
31	Simple Linear Regression III	• Produce residual plots and a normal-probability plot for a fitted regression model. (SLO 2, 4) • Assess the assumptions of linear regression and judge model adequacy. (SLO 4, 6)	13.1	—
32	Multiple Linear Regression I	• State the multiple regression model. (SLO 4) • Estimate and interpret the partial-slope coefficients of a multiple regression model. (SLO 4) • Interpret standard regression output from statistical software. (SLO 4)	13.4	—
33	Multiple Linear Regression II	• Assess the assumptions of the multiple regression model and judge model adequacy. (SLO 4, 6) • Interpret the coefficient of multiple determination R^2 and adjusted R^2. (SLO 4) • Incorporate categorical predictors using indicator (dummy) variables and interpret their coefficients. (SLO 4)	13.4 13.5 S4	—
34	Project IPR	• Seek and incorporate instructor and peer feedback on the project analysis and presentation. (SLO 1)		—
35	ANOVA I	• State the assumptions and hypotheses for single-factor (one-way) ANOVA. (SLO 5) • Compute the F statistic from the ANOVA table (sums of squares and mean squares) and carry out the F test. (SLO 4) • Interpret the P-value and conclude whether the population means differ. (SLO 5)	10.1	10.1: 002, 003, 005, 006
36	ANOVA II	• Apply Tukey's multiple-comparisons procedure to identify which population means differ. (SLO 5) • Interpret Tukey's results and acknowledge what one-way ANOVA and Tukey do and do not establish. (SLO 5, 6)	10.2	10.2: 011, 013, 016, 018
37	Project Drop	Project drop.		—
38	Project Presentations I	• Present the statistical investigation and conclusions to a general audience. (SLO 1) • Respond to questions and defend analytical choices. (SLO 1, 6)		—

LSN	Topic	Lesson Objective	Read	WebAssign
39	Project Presentations II	• Present the statistical investigation and conclusions to a general audience. (SLO 1) • Respond to questions and defend analytical choices. (SLO 1, 6)		—
40	Cadet-Led Review	Review course material in preparation for the Term End Exam.		—

Textbook

The text for this class is *Probability and Statistics for Engineering and the Sciences*, 9th Ed., by Jay Devore. All readings are out of the text except for posted supplemental readings on Canvas; these are labeled S1, S2, and so on in the Read column and posted on Canvas. You will also need access to the Cengage WebAssign platform for lesson preparation; access instructions are on Canvas. WebAssign problem numbers listed in the lesson tables follow the Cengage WebAssign course for this text (10th-edition / "PSES10" numbering); section numbers align with the 9th-edition readings. WebAssign homework is due at the start of the lesson indicated.

Course Policies

1. All assignments are due by the due date posted in Canvas, **except** WebAssign homework, which is due at the start of class that lesson (ignore exact Canvas due dates). Late assignments are deducted 10% per 24-hour period elapsed from the published date-time group.
2. Generative AI use is governed by the Artificial Intelligence section below. Document and acknowledge all assistance IAW the current DAAW and follow the assignment-specific guidance.

Artificial Intelligence

The Academy authorizes generative AI at the assignment level, as specified by course and instructor guidance. Every graded event in this course identifies one of the three Academy AI-Use Levels:

Table 4: Academy AI-Use Levels

Level	Description
0	Individual work, AI prohibited. Generative AI may not be used in completing the assignment.
1	Partial teaming, AI permitted. Generative AI may be used within instructor-established limits, with all DAAW documentation and acknowledgment requirements met.
2	Full teaming, AI integrated. Generative AI is intentionally built into the learning activity. You are expected to use it while exercising professional judgment, critically evaluating its output, verifying accuracy, and documenting and acknowledging the assistance IAW the DAAW.

In MA206 we operate at Level 1 for WebAssign homework, at Level 2 for out-of-class assignments, including the course project, and at Level 0 for in-class assignments, including the WPRs and the TEE. Your instructor will provide clarification and any assignment-specific limits; ask them when you are unsure, and never assume a level that an assignment has not stated.

Regardless of the authorized level, you remain responsible for the accuracy, reasoning, citations, calculations, programming, integrity, and final quality of everything you submit.

Recording-based AI note-taking technologies are prohibited during classroom instruction. This includes AI note-taking and transcription apps, AI-enabled smart glasses, and any similar wearable or recording device.

Grade Breakdown

Graded Event	Points
WebAssign Homework	150
WPR I	175

Graded Event	Points
WPR II	175
Project	**200**
EDA	25
IPR	25
Products	50
Brief	100
TEE	300
Total	**1000**

Course Project

Throughout this course you will execute a statistical investigation into data hosted inside the Army Vantage enterprise using actual data from an Army unit. You are expected to work on this project concurrently with the other requirements of the course. To gain access to Army Vantage you will need an account (instructions on Canvas). You will pick one of the five published unit-level datasets as your project dataset.

The project is graded in four events:

Table 5: Course project graded events

Event	Lesson	Requirement	Points
EDA	14 (23-24 Sep)	One page: research question, decision maker, the construct you intend to measure, proxy justification, and initial exploratory analysis. Your instructor will approve the question or redirect it.	25
IPR	34 (20-23 Nov)	Present your work in its current state for instructor and peer feedback. Credit is for participation, though the feedback you receive is only as useful as the work you bring.	25
Products	37 (3-4 Dec)	Slide deck, executive summary, and analysis code submitted in Canvas.	50
Brief	38-39 (7-10 Dec)	Five-minute BLUF brief followed by a ten-minute defense led by your instructor.	100
Total			**200**