MTH 540/640: Statistical Theory I (Spring 2024)

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Room and Time: Cheek Hall 173, 9:05am – 9:55am, MWF

Office and Hours: Cheek Hall 22M, 8:30am – 11:00am, Tuesday and Thursday; or by appointment. It is a better idea to formulate your question in email, and if it is easy to explain your question in email, I will reply to your email immediately when I see it. Alternatively, you can also make an appointment for a Zoom meeting, and the Meeting ID is **8514343306**.

Textbooks: Probability and Statistics, 4th Edition, by Morris H. DeGroot, and Mark J. Schervish.

Lecture notes will be available.

Course webpage:

http://people.missouristate.edu/songfengzheng/Teaching/MTH540S24.htm will provide the download of various course materials, including the lecture notes, homework assignments, announcements, and data for exercises.

Objectives & Prerequisites: The course MTH 540/640 is devoted to probability theory, which is widely used in modern sciences and technologies. Students will be equipped with probability theory, thoughts, and methodology when they leave the course; also students are expected to be able to solve practical application problems. The prerequisite for this course is MTH 302 and MTH 315, or equivalent; students are expected to be familiar with calculus (differentiation, integral of single variant function and double integral, change the order of integral, sum of infinite series). Previous courses about probability and statistics are not required but definitely a plus.

Materials to be covered (tentative): Events, calculus of events, interpretation of probability, calculating probability for different events. Counting methods. Bayesian formula. Random variables, discrete and continuous probability functions, expectation and variances, moment-generating functions and properties, multi-variate probability distributions, marginal and conditional distributions, transformation of variables, Central limit theorem and applications, commonly used probability distribution models.

Grading Policy and Studying Suggestions:

Homework: 20% In-class Tests: 40% Final Exam: 40%

Grading policy: A (>90%) B (80 --- 89%) C (70 --- 80%) D (60 – 70%), F(<60%)

Final Exam date: 8:45am --- 10:45am, Monday, May 6th, 2024.

Note: students enrolled in MTH640 are expected to finish one more question in each exam, or finish an additional project!

It is important that you read the textbook and lecture notes regularly, understand the problems worked out in the text and practice by doing the problems. Doing the homework problems is absolutely essential to get a better grade in this course. You are allowed to discuss the homework problems among yourselves or with me. However, the final work handed in must be completely your own. Anyone who receives or gives an unauthorized aid on a homework or test is considered to be cheating. **Late Homework will not be accepted!**

There will be two midterm exams. The midterm exam dates will be announced in class (and on the course webpage) about two weeks ahead. The final exam will be comprehensive! No make-up test or exam will be given under ordinary conditions. The only acceptable excuse for missing a test is an extreme emergency. However, you must obtain a written explanation from a physician, etc. **If you cannot take the test on the scheduled day, you must contact me at least three days before the test.**

Emailing format:

Email is an important means to communication in this course. Due to the large amount of emails sent to me every day, and due to different courses I am teaching, I suggest you clearly write a subject in the email, and in the subject, clearly tell which course you are from. For example, a good email subject would be like

Subject: MTH 540: Q about #4 in HW2

Thus, I can quickly locate your problem and will reply quickly. Emails which don't have a clear subject might be simply ignored!

Classes During Campus Closures

When the university is closed due to an emergency or inclement weather situation, classes will move to remote learning. What this means for our class is that we will meet via Zoom during our regularly scheduled class time OR you will complete and submit an alternative online assignment by the specified due date OR I will post alternative materials for you to read/review. I will use email to communicate any changes to scheduled tests, quizzes, or other assessments that may be impacted. If

you are not able to participate in the remote learning activities as described (for example, due to a power outage), you should contact me as soon as you can so alternative arrangements can be made.

Changes to this syllabus:

The instructor reserves the right to make changes to this syllabus, and the changes will be announced in class and on the course webpage.

Miscellaneous Notes:

Attendance policy: The University expects instructors to be reasonable in accommodating students whose absence from class resulted from: (1) participation in University-sanctioned activities and programs; (2) personal illness; or (3) family and/or other compelling circumstances. Instructors have the right to request documentation verifying the basis of any absences resulting from the above factors. Please see The University's attendance policy can be found in the *2010-2011 Undergraduate Catalog* at www.missouristate.edu/registrar/attendan.html.

Academic dishonesty: Missouri State University is a community of scholars committed to developing educated persons who accept the responsibility to practice personal and academic integrity. You are responsible for knowing and following the university's academic integrity policy plus additional more-specific policies for each class. The university policy, formally known as the "Student Academic Integrity Policies and Procedures" is available online at Academic Integrity Policies and Procedures (Students) and also at the Reserves Desk in Meyer Library. Any student participating in any form of academic dishonesty will be subject to sanctions as described in this policy.

Nondiscrimination: Missouri State University is an equal opportunity/affirmative action institution, and maintains a grievance procedure available to any person who believes he or she has been discriminated against. At all times, it is your right to address inquiries or concerns about possible discrimination to the Office for Institutional Equity and Compliance, Park Central Office Building, 117 Park Central Square, Suite 111, 417-836-4252. Other types of concerns (i.e., concerns of an academic nature) should be discussed directly with your instructor and can also be brought to the attention of your instructor's Department Head. Please visit the OIEC website.

Disability accommodation: If you are a student with a disability and anticipate barriers related to this course, it is important to request accommodations and establish an accommodation plan with the University. Please contact the Disability Resource Center (DRC) at the Disability Resource Center website, Meyer Library, Suite 111, 417-836-4192, to initiate the process to establish your accommodation

plan. The DRC will work with you to establish your accommodation plan, or it may refer you to other appropriate resources based on the nature of your disability. In order to prepare an accommodation plan, the University usually requires that students provide documentation relating to their disability. Please be prepared to provide such documentation if requested. Once a University accommodation plan is established, you may notify the class instructor of approved accommodations. If you wish to utilize your accommodation plan, it is suggested that you do so in a timely manner, preferably within the first two weeks of class. Early notification to the instructor allows for full benefit of the accommodations identified in the plan. Instructors will not receive the accommodation plan until you provide that plan, and are not required to apply accommodations retroactively.

Cell phone policy: As a member of the learning community, each student has a responsibility to other students who are members of the community. When cell phones or pagers ring and students respond in class or leave class to respond, it disrupts the class. Therefore, the Office of the Provost prohibits the use by students of cell phones, pagers, PDAs, or similar communication devices during scheduled classes. All such devices must be turned off or put in a silent (vibrate) mode and ordinarily should not be taken out during class. Given the fact that these same communication devices are an integral part of the University's emergency notification system, an exception to this policy would occur when numerous devices activate simultaneously. When this occurs, students may consult their devices to determine if a university emergency exists. If that is not the case, the devices should be immediately returned to silent mode and put away. Other exceptions to this policy may be granted at the discretion of the instructor.

Emergency response: At the first class meeting, students should become familiar with a basic emergency response plan through a dialogue with the instructor that includes a review and awareness of exits specific to the classroom and the location of evacuation centers for the building. All instructors are provided this information specific to their classroom and/or lab assignments in an e-mail prior to the beginning of the fall semester from the Office of the Provost and University Safety. Students with disabilities impacting mobility should discuss the approved accommodations for emergency situations and additional options when applicable with the instructor. For more information, visit University Safety.

Tentative Lecture Schedule in Spring 2024 (MTH 540/640)

Lecture 1: introduction, experiment, event, relation between events, set operations.

Lecture 2: event operations for more events, finite sample space, Axioms of probability.

Lecture 3: Properties of probability. Example.

Lecture 4: Multiplication rule, Examples.

Lecture 5: Permutation and Combinations.

Lecture 6: Examples, Partition problems.

Lecture 7: Conditional probability.

Lecture 8: Multiplication formula for probability, Independent events.

Lecture 9: Independent Events, Examples.

Lecture 10: Total probability formula, Bayes rule, Examples.

Lecture 11: Bayes rule, Examples. Random variables.

Lecture 12: Notations for Random variables, Discrete Random variables, probability functions, Examples.

Lecture 13: Bernoulli R.V., Binomial R.V., cumulative distribution function of discrete R.V.

Lecture 14: Continuous R.V., probability density function, Cauchy distribution, Normal distribution.

Lecture 15: cumulative distribution function, exponential distribution, functions of random variable, chi-square distribution.

Lecture 16: p.d.f. of transformed random variable when the transformation is invertible.

Lecture 17: Examples of transformed R.V. Joint discrete random variables.

Lecture 18: Joint continuous random variables, joint p.d.f., Examples.

Lecture 19: Examples for calculating probability from joint p.d.f.

Lecture 20: Bivariate Distribution function. Example.

Lecture 21: marginal p.d.f., Independent random variables. Examples.

Lecture 22: Factorization theorem for independent random variables, conditional p.d.f., Examples.

Lecture 23: Examples for conditional p.d.f.

Lecture 24: continuous Bayes formula, example.

Lecture 25: Bivariant transformation, Jacobian matrix, and the joint pdf after transformation.

Lecture 26: joint pdf of n random variable and related concepts, iid random variables.

Lecture 27: Expectation of discrete and continuous random variables. Expectation of function.

Lecture 28: Variance, Expectation of multivariant random variables, property of expectation.

Lecture 29: Properties of Expectation.

Lecture 30: variance of sum of independent random variables, covariance, properties of covariance.

Lecture 31: variance of linear combinations of random variables, correlation coefficient, property of correlation coefficient.

Lecture 32: Cauchy-Schwartz Inequality; moment generating function and examples.

Lecture 33: Moments, relation between moments and moment generating function. Example of Binomial distribution.

Lecture 34: moment generating function of linear combination of independent random variables, determining distribution from moment generating function.

Lecture 35: Central Limit Theorem and Its Proof.

Lecture 36: Bernoulli Distribution, Binomial Distribution, and Geometric Distribution.

Lecture 37: Poisson Distribution, Normal Distribution. Properties of Poisson and Normal Distributions.

Lecture 38: Linear combination of independent normal random variables. Gamma function and properties. Gamma distribution, Expectation and variance of Gamma distribution.

Lecture 39: Moment generating function of gamma distribution, exponential distribution, chi square distribution.

Lecture 40: Beta distribution, Markov Inequality, Chebyshev Inequality, Law of Large Numbers.

Lecture 41: Relationship between Normal distribution and Chi-square distribution. Example.

Lecture 42: Multinomial distribution: definition, probability function, marginal distribution, covariance. Conditional expectation and conditional variance: definitions.