Course Title	**Optimal Design Theory and Applications** **BIOSTAT 279**
Credit	4 units
Term	Spring 2021
Instructor	**Weng Kee Wong, PhD** Department of Biostatistics Fielding School of Public Health CHS 51-239B University of California, Los Angeles Phone: (310) 206-9622; Email address: wkwong@ucla.edu
Office Hour	TBA
Class Hours	Lectures and Discussion: Monday and Thursday 4.30-6.00pm
Location	Online
Course Description	This class covers optimal design of experiments for linear and nonlinear regression models with biomedical applications, including designs for dose-response studies and adaptive designs for early phase clinical trials. We discuss various optimality criteria, statistical methodology and algorithms to find and confirm optimality of a design. Optimal designs of interest include locally D- and D_s-optimal, c-optimal, L-optimal, Bayeisan, maximin and multiple-objective optimal designs. Students are expected to write and implement codes to generate and compare different types of optimal designs.
Prerequisites	Students are expected to have a solid Mathematical Statistics and Algebra training at the beginning graduate level with programming skills.
References	1 Optimum Experimental Designs with SAS by Atkinson, A. C., Donev, A. N. and Tobias, R. D. Oxford University Press, 2007. 2 An Introduction to Optimum Designs for Social and Biomedical Research by Berger, M. P. F. and Wong, W. K. John Wiley& Sons, 2009. 3 Theory of Optimal Experiments by Fedorov, V. V. Academic Press, 1972. 4 Foundations of Optimum Experimental Design by Pazman, A. D. Reidel Publishing Company. 5 Sample Size Calculations in Clinical Research, 2nd edition by S. C. Chow, J. Shao and H. Wang. Chapman and Hall/CRC, 2008. 6 Randomization in Clinical Trials: Theory and Practice by W. F. Rosenberger and J. M. Lachin. Wiley. 2002. 7 Swarm Intelligence Methods for Statistical Regression by Soumya Mohanty. CRC Press.

Class Notes	Class attendance is an important and necessary element for successful completion of the class. You are expected to attend every discussion and lecture session. Discussion sessions will be announced periodically and they may be used for discussion of homework problems, further discussion on lecture material or new material. Students learn from each other as well as from the instructor and are therefore highly encouraged to discuss homework assignments with classmates. However, students **must** write out their own solutions for the lab and homework assignments. Incompletes will be given only under extraordinary circumstances. In line with University policy, the guidelines and policy for academic integrity will be enforced. Please refer to the UCLA policy provisions.
Methods of Evaluation	Homework will be assigned periodically. Students must be prepared to present their solutions to homework problems during the discussion classes. Organization and clarity of your solutions to the homework problems are emphasized. Each student or group of students will also give a 35-minute oral presentation on a selected topic on the design or analysis of clinical trials. The topic must be chosen and approved by the instructor by **May 3rd**. In addition, a written report that follows up on the presentation is required. The report should be about 20 pages, including all tables and figures and prepared using 11-point font, double-spaced, well organized. Please email your slides 10 days in advance of your class presentation date to the instructor via email (wkwong@ucla.edu) and a hard copy of your written report by 1**2.00pm on Wednesday 6/12/2021**.

Grading Scheme	Homework and Discussion	15%
	In-class Presentation for 30 minutes on a pre-approved topic*	35%
	Written Project Report (due 6/12/21)	50%

	Learning Objectives	***ASPH Competencies***
1	Able to identify different types of data and designs that arise naturally in the health sciences and appreciate their unique features and use in public health research.	A.1 Describe the roles biostatistics serves in the discipline of public health.
2	Able to use the software packages like Mathematica or MATLAB and write codes to find different types of optimal designs using metaheuristic algorithms, or otherwise.	A.6 Develop design methodologies according to the type of study and objective or objectives for the research questions.
3	Able to select an appropriate statistical design to draw inference for biomedical studies.	A.3 Describe various methodological alternatives to commonly used statistical designs when standard assumptions are not met.

Time	Tentative Syllabus for Biostatistics 279 with material from online sources:
Week 1: 3/29-4/1	Lecture 1: Class organization and expectation. Overview of optimal design issues with examples of optimal allocation schemes in biomedical settings. Exact and approximate designs. Uniform designs. How to compare designs? Lecture 2: Principles of a good experimental design. Choice of a good design. Model-based optimal designs and Fisher information matrices under various assumptions on the error distribution.
Week 2: 4/5-4/8	Lecture 3: Review matrix results such as Spectral Decomposition Theorem for solving design problems. Convex analysis results for constructing optimal approximate designs. Lecture 4: Equivalence theorems and examples of various optimal designs for biomedical applications. How to use Mathematica software to find optimal experimental designs. Discussion.
Week 3: 4/12-4/15	Lecture 5: Examples of optimal designs; heteroscedastic linear models. Invariance properties of optimal designs with examples. Locally optimal designs for nonlinear models. Exercises in constructing various types of optimal designs for different types of models. Lecture 6: Proofs of equivalence theorems and related results.
Week 4: 4/19-4/22	Lecture 7: Optimal designs for generalized linear models for biomedical studies. Lecture 8: Algorithmic construction of optimal designs. Discussion.
Week 5: 4/26-4/29	Lecture 9: Nature-inspired metaheuristic algorithms for finding optimal designs. Lecture 10: Bayesian optimal designs and maximin optimal designs.
Week 6: 5/3-5/6	Lecture 11: Multiple-objective optimal design methodology with applications. Lecture 12: An illustrative use of a multiple-objective design for a 4-parameter logistic regression model in a dose-response study. Discussion.
Week 7: 5/10-5/13	Lecture 13: Clinical Trials – Different study designs. Randomization schemes like Efron's biased coin design, urn model schemes, minimization method, and optimal allocation strategies. Lecture 14: Designs for early phase trials.
Week 8: 5/17-5/20	Lecture 15: Response adaptive randomization plans that target an optimal allocation ratio. Lecture 16: Adaptive Design Strategies. Sample size determination for various biomedical studies. Discussion
Week 9: 5/24-5/27	Lecture 17: Sample size determination for various biomedical studies. Lecture 18: Project presentations from students.
Week 10: 5/31–6/3	Lecture 19: Memorial Day Holiday. Lecture 20: Project presentations from students.