Subject Description Form

Subject Code	AMA620
Subject Title	Advanced Statistical Learning
Credit Value	3
Level	6
Pre-requisite	A course in college calculus, college linear algebra, and basic mathematical statistics
Objectives	The objectives of this course are to introduce the most important and modern methods, theory and algorithms in statistical learning and provide a solid foundation for graduate students who are interested in working in data science and related fields.
Intended Learning Outcomes *(Note 1)*	Upon completion of the subject, students will be able to: a. Have a good understanding of the basic theory and methods of modern statistical learning. b. Know how to assess statistical uncertainties for conclusions based on data and statistical analysis. c. Develop and implement new methods that are appropriate for specific data problems in applications. d. Be well prepared for conducting methodological and applied research in statistical learning and the related fields.
Subject Synopsis/ Indicative Syllabus *(Note 2)*	**Introduction** Overview of statistical learning Review of nonparametric statistics Review of high-dimensional statistics **Deep Neural Networks** Deep neural network functions Nonparametric regression using deep neural networks Approximation properties of deep neural networks Empirical process theory for stochastic error analysis Error analysis for deep nonparametric regression **Distribution Learning** Nonparametric density estimation Generative learning: GANs, VAE

	Diffusion models Error analysis for distribution learning Applications **Conditional Distribution Learning** Nonparametric conditional density estimation Conditional generative learning Supervised learning Semi-supervised learning Prediction: conformal prediction Error analysis for conditional distribution learning Applications **Learning and Optimization** Difference between learning and optimization Challenges in neural network optimization Stochastic gradient descent **Representation learning (time permitting)** Supervised representation learning Self-supervised learning Applications: Transfer learning and domain adaptation
Teaching/Learning Methodology *(Note 3)*	The subject will be delivered mainly through lectures and tutorials, and class discussions, questions, and answers. Additional reading of relevant books and research papers will be encouraged. The teaching and learning approach are mainly problem-solving oriented. The approach aims at the development of statistical learning methods, theories, and algorithms and how they can be applied to solving research and real application problems. Students are encouraged to adopt a deep study approach by employing high level cognitive strategies, such as critical and evaluative thinking, relating, integrating, and applying theories to practice.

Assessment Methods in Alignment with Intended Learning Outcomes *(Note 4)*	(see table below)

Specific assessment methods/tasks	% weighting	Intended subject learning outcomes to be assessed (Please tick as appropriate)				
		a	b	c	d	
Assignment	20%	✓			✓	
Quiz	20%	✓	✓			
Projects	60%	✓	✓	✓	✓	
Total	100%					

Explanation of the appropriateness of the assessment methods in assessing the intended learning outcomes:

Assignment: assessment of the understanding the basic concepts and the ability for self-learning by acquiring knowledge from published works and online information.
Quiz: assessment of the ability for comprehension of fundamental concepts, principles, algorithms, and theories by providing answers to given questions.
Project: assessment of the ability for developing methods and algorithms for solving practical problems. The results will be presented in written reports and oral presentations.

Student Study Effort Expected		
	Class contact:	
	▪ Lectures	26 Hrs.
	▪ Tutorials	13 Hrs.
	Other student study effort:	
	▪ Assignment	30 Hrs.
	▪ Self-study	61 Hrs.
	Total student study effort	130 Hrs.

Reading List and References

- Anthony, M. and Barttlett, P. L. (2009). Neural Network Learning: Theoretical Foundations. Cambridge University Press, Cambridge.
- Bishop, C. (2006). Pattern Recognition and Machine Learning. Springer.
- Boucheron, S., Lugosi, G., and Massart, P. (2013). Concentration Inequalities: A Nonasymptotic Theory of Independence. Oxford University Press.
- Hastie, T., Tibshirani, R. and Friedman, J. (2009). The Elements of Statistical Learning, 2nd Ed., Springer.

	• Hastie, T., Tibshirani, R., and Wainright, M. (2015), Statistical Learning with Sparsity:The Lasso and Generalizations, Chapman and Hall. • Mohri, Mehryar; Rostamizadeh, Afshin; Talwalkar, Ameet (2012). Foundations of Machine Learning. USA, Massachusetts: MIT Press. • Ian Goodfellow, Yoshua Bengio and Aaron Courville (2017). Deep Learning. The MIT Press, Cambridge, MA. • Van der Vaart A. W. and Wellner, J. A. (1996). Weak Convergence and Empirical Processes. Springer, New York.