



CS229

# CS229: Machine Learning - The Summer Edition!

**Course Description** This is the summer edition of CS229 Machine Learning that was offered over 2019 and 2020. CS229 provides a broad introduction to statistical machine learning (at an intermediate / advanced level) and covers supervised learning (generative/discriminative learning, parametric/non-parametric learning, neural networks, support vector machines); unsupervised learning (clustering, dimensionality reduction, kernel methods); learning theory (bias/variance tradeoffs, practical ); and reinforcement learning among other topics. **The structure of the summer offering enables coverage of additional topics, places stronger emphasis on the mathematical and visual intuitions, and goes deeper into the details of various topics.**

## Full playlist (YouTube)

## Syllabus and Course Schedule

Event	Date	Description	Materials and Assignments
<b>Introduction and Pre-requisites review</b> (3 lectures)			
Lecture 1 <a href="#">[YouTube]</a>	6/24	<ul style="list-style-type: none"> <li>• Introduction and Logistics</li> <li>• Review of Linear Algebra</li> </ul>	<b>Class Notes</b> <ul style="list-style-type: none"> <li>• Introduction <a href="#">[pptx]</a></li> <li>• Linear Algebra (section 1-3) <a href="#">[pdf]</a></li> </ul>
Lecture 2 <a href="#">[YouTube]</a>	6/26	<ul style="list-style-type: none"> <li>• Review of Matrix Calculus</li> <li>• Review of Probability</li> </ul>	<b>Class Notes</b> <ul style="list-style-type: none"> <li>• Linear Algebra (section 4) <a href="#">[pdf]</a></li> <li>• Probability Theory <a href="#">[pdf]</a></li> <li>• Probability Theory Slides <a href="#">[pdf]</a></li> </ul>
Lecture 3 <a href="#">[YouTube]</a>	6/28	<ul style="list-style-type: none"> <li>• Review of Probability and Statistics</li> <li>• Setting of Supervised Learning</li> </ul>	<b>Class Notes</b> <ul style="list-style-type: none"> <li>• Supervised Learning <a href="#">[pdf]</a></li> <li>• Probability Theory <a href="#">[pdf]</a></li> </ul>
<b>Supervised Learning</b> (8 lectures)			
Lecture 4 <a href="#">[YouTube]</a>	7/1	<ul style="list-style-type: none"> <li>• Linear Regression</li> <li>• [Stochastic] Gradient Descent ([S]GD)</li> <li>• Normal Equations</li> <li>• Probabilistic Interpretation</li> <li>• Maximum Likelihood Estimation (MLE)</li> </ul>	<b>Class Notes</b> <ul style="list-style-type: none"> <li>• Supervised Learning (section 1-3) <a href="#">[pdf]</a></li> </ul>
Lecture 5 <a href="#">[YouTube]</a>	7/3	<ul style="list-style-type: none"> <li>• Perceptron</li> <li>• Logistic Regression</li> <li>• Newton's Method</li> </ul>	<b>Class Notes</b> <ul style="list-style-type: none"> <li>• Supervised Learning (section 5-7) <a href="#">[pdf]</a></li> </ul>

Event	Date	Description	Materials and Assignments
Lecture 6 <a href="#">[YouTube]</a>	7/5	<ul style="list-style-type: none"> <li>Exponential Family</li> <li>Generalized Linear Models (GLM)</li> </ul>	<b>Class Notes</b> <ul style="list-style-type: none"> <li>Supervised Learning (section 8-9) <a href="#">[pdf]</a></li> </ul>
Lecture 7 <a href="#">[YouTube]</a>	7/8	<ul style="list-style-type: none"> <li>Gaussian Discriminant Analysis (GDA)</li> <li>Naive Bayes</li> <li>Laplace Smoothing</li> </ul>	<b>Class Notes</b> <ul style="list-style-type: none"> <li>Generative Algorithms <a href="#">[pdf]</a></li> </ul>
Lecture 8 <a href="#">[YouTube]</a>	7/10	<ul style="list-style-type: none"> <li>Kernel Methods</li> <li>Support Vector Machine</li> </ul>	<b>Class Notes</b> <ul style="list-style-type: none"> <li>Kernel Methods and SVM <a href="#">[pdf]</a></li> </ul>
Lecture 9 <a href="#">[YouTube]</a>	7/12	<ul style="list-style-type: none"> <li>Bayesian Methods</li> <li>Parametric (Bayesian Linear Regression)</li> <li>Non-parametric (Gaussian process)</li> </ul>	<b>Class Notes</b> <ul style="list-style-type: none"> <li>Gaussian Processes <a href="#">[pdf]</a></li> </ul> <b>Optional</b> <ul style="list-style-type: none"> <li>The Multivariate Gaussian Distribution <a href="#">[pdf]</a></li> <li>More on Gaussian Distribution <a href="#">[pdf]</a></li> </ul>
Lecture 10 <a href="#">[YouTube]</a>	7/15	<ul style="list-style-type: none"> <li>Neural Networks and Deep Learning</li> </ul>	<b>Class Notes</b> <ul style="list-style-type: none"> <li>Deep Learning (skip Sec 3.3) <a href="#">[pdf]</a></li> </ul> <b>Optional</b> <ul style="list-style-type: none"> <li>Backpropagation <a href="#">[pdf]</a></li> </ul>
Lecture 11 <a href="#">[YouTube]</a>	7/17	<ul style="list-style-type: none"> <li>Deep Learning (contd)</li> </ul>	
<b>Theory (2 lectures)</b>			

Event	Date	Description	Materials and Assignments
Lecture 12 <a href="#">[YouTube]</a>	7/19	<ul style="list-style-type: none"> <li>Bias and Variance</li> <li>Regularization, Bayesian Interpretation</li> <li>Model Selection</li> </ul>	<b>Class Notes</b> <ul style="list-style-type: none"> <li>Regularization and Model Selection <a href="#">[pdf]</a></li> </ul>
Lecture 13 <a href="#">[YouTube]</a>	7/22	<ul style="list-style-type: none"> <li>Bias-Variance tradeoff (wrap-up)</li> <li>Empirical Risk Minimization</li> <li>Uniform Convergence</li> </ul>	<b>Class Notes</b> <ul style="list-style-type: none"> <li>Bias Variance Analysis <a href="#">[pdf]</a></li> <li>Statistical Learning Theory <a href="#">[pdf]</a></li> </ul>
<b>Reinforcement Learning</b> (2 lectures)			
Lecture 14 <a href="#">[YouTube]</a>	7/24	<ul style="list-style-type: none"> <li>Reinforcement Learning (RL)</li> <li>Markov Decision Processes (MDP)</li> <li>Value and Policy Iterations</li> </ul>	<b>Class Notes</b> <ul style="list-style-type: none"> <li>Reinforcement Learning and Control (Sec 1-2) <a href="#">[pdf]</a></li> </ul>
Lecture 15 <a href="#">[YouTube]</a>	7/26	<ul style="list-style-type: none"> <li>RL (wrap-up)</li> <li>Learning MDP model</li> <li>Continuous States</li> </ul>	<b>Class Notes</b> <ul style="list-style-type: none"> <li>Reinforcement Learning and Control (Sec 3-4) <a href="#">[pdf]</a></li> </ul>
<b>Unsupervised Learning</b> (3 lectures)			
Lecture 16 <a href="#">[YouTube]</a>	7/29	Unsupervised Learning <ul style="list-style-type: none"> <li>K-means clustering</li> <li>Mixture of Gaussians (GMM)</li> <li>Expectation Maximization (EM)</li> </ul>	<b>Class Notes</b> <ul style="list-style-type: none"> <li>K-means <a href="#">[pdf]</a></li> <li>Mixture of Gaussians <a href="#">[pdf]</a></li> <li>Expectation Maximization (Sec 1-2, skip 2.1) <a href="#">[pdf]</a></li> </ul>

Event	Date	Description	Materials and Assignments
Lecture 17 <a href="#">[YouTube]</a>	7/31	<ul style="list-style-type: none"> <li>• EM (wrap-up)</li> <li>• Factor Analysis</li> </ul>	<b>Class Notes</b> <ul style="list-style-type: none"> <li>• Expectation Maximization (Sec 3) <a href="#">[pdf]</a></li> <li>• Factor Analysis <a href="#">[pdf]</a></li> </ul>
Lecture 18 <a href="#">[YouTube]</a>	8/2	<ul style="list-style-type: none"> <li>• Factor Analysis (wrap-up)</li> <li>• Principal Components Analysis (PCA)</li> <li>• Independent Components Analysis (ICA)</li> </ul>	<b>Class Notes</b> <ul style="list-style-type: none"> <li>• Principal Components Analysis <a href="#">[pdf]</a></li> <li>• Independent Components Analysis <a href="#">[pdf]</a></li> </ul>
<b>Miscellaneous Topics</b> (3 lectures)			
Lecture 19	8/5	<ul style="list-style-type: none"> <li>• Maximum Entropy and Exponential Family</li> <li>• KL-Divergence</li> <li>• Calibration and Proper Scoring Rules</li> </ul>	<b>Class Notes</b> <ul style="list-style-type: none"> <li>• Maximum Entropy <a href="#">[pdf]</a></li> </ul>
Lecture 20	8/7	<ul style="list-style-type: none"> <li>• Variational Inference</li> <li>• EM Variants</li> <li>• Variational Autoencoder</li> </ul>	<b>Class Notes</b> <ul style="list-style-type: none"> <li>• VAE (Sec 4) <a href="#">[pdf]</a></li> </ul>
Lecture 21	8/9	<ul style="list-style-type: none"> <li>• Evaluation Metrics</li> </ul>	<b>Class Notes</b> <ul style="list-style-type: none"> <li>• Evaluation Metrics <a href="#">[pptx]</a></li> </ul>
<b>Recap and wrap-up</b> (2 lectures)			
Lecture 22	8/12	<ul style="list-style-type: none"> <li>• Practical advice and tips</li> <li>• Review for Finals</li> </ul>	<b>Class Notes</b>

Event	Date	Description	Materials and Assignments
Lecture 23	8/14	<ul style="list-style-type: none"><li>• Review for Finals</li></ul>	<b>Class Notes</b>
Final	8/16		

### Other Resources

1. Advice on applying machine learning: Slides from Andrew's lecture on getting machine learning algorithms to work in practice can be found [here](#).
2. Previous projects: A list of last year's final projects can be found [here](#).
3. Data: Here is the [UCI Machine learning repository](#), which contains a large collection of standard datasets for testing learning algorithms. If you want to see examples of recent work in machine learning, start by taking a look at the conferences [NeurIPS](#) (all old NeurIPS papers are online) and ICML. Some other related conferences include UAI, AAAI, IJCAI.
4. Viewing PostScript and PDF files: Depending on the computer you are using, you may be able to download a [PostScript](#) viewer or [PDF viewer](#) for it if you don't already have one.
5. [Machine learning study guides tailored to CS 229](#) by Afshine Amidi and Shervine Amidi.