Detailed Syllabus with references (APPM 4470/5470 Advanced Convex Optimization, Fall 2018, Stephen Becker)

Week	Mon		Wed		Fri	
1	*Aug 27*	NO CLASSES	*Aug 29*	Intro	*Aug 31*	Intro
2	*Sep 3*	Convex Sets [BV04 ch 2]	*Sep 5*	cvx, cvxpy tutorial	*Sep 7*	Convex sets, PSD cone, separating hyperplanes [BV04 ch2]
3	*Sep 10*	Convex functions [BV04 ch 3]	*Sep 12*	Convex functions, subgradients, commuting addition and subgradients [BC11]	*Sep 14*	subgradients, more on convex fcn not from [BV04], strong/strict convexity; see handout on Lipschitz bounds
4	*Sep 17*	Convex functions, sections 3.1--3.3 in [BV04] (Fenchel-Legendre conjugate functions)	*Sep 19*	3.3 in [BV04], convex relaxation f^** [BC11], Fenchel-Young	*Sep 21*	convex relaxation f^** [BC11], [Luc10]; existence/uniqueness of minimizers [BC11 ch 11]; proximity operator [BC11, CP11]
5	*Sep 24*	prox, Moreau envelope [CW05]	*Sep 26*	prox, Moreau envelope [CW05]; Convex Optimization [BV04 ch 4]; gradient descent	*Sep 28*	convergence of gradient descent [Van16]; fire drill!
6	*Oct 1*	worst-case counter-example for 1st order methods [Nes04]	*Oct 3*	Convex Optimization [BV04 ch 4.2]	*Oct 5*	Convex Optimization, LP/QP/SOCP/SDP [BV04 ch 4.2-3, 4.6]
7	*Oct 8*	SDP/LMI [BV04 ch 4.6], Duality and Lagrangians [BV04 ch 5.1]	*Oct 10*	LP duality [Van08], sensible rules for remembering duals (SOB) [Ben95], Slater	*Oct 12*	Slater and strong duality [BV04 ch5.2], geometric interpretation [BV04 ch5.3]
8	*Oct 15*	Game theory [BV04 ch 5.2.5; 5.4.3], saddle point interpretation [BV04 ch 5.4]; some Fenchel-Rockafellar duality	*Oct 17*	Fenchel-Rockafellar duality [BC11, chs15,18-19]	*Oct 19*	Optimality and KKT conditions [BV04 ch5.5], perturbation and sensitivity [BV04 ch5.6]
9	*Oct 22*	perturbation and sensitivity [BV04 ch5.6], generalized inequalities (eg. SDP) [BV04 ch5.9]	*Oct 24*	Interlude on proximal [CW05] [Van16] and accelerated (Nesterov) gradient methods [Nes04][Van16][BT10]; convergence rates	*Oct 26*	Fast/fancy algorithms for unconstrained optimization [NW05]: Nesterov, Newton, linear/non-linear conjugate gradient
10	*Oct 29*	Fast/fancy algorithms for unconstrained optimization [NW05]: quasi-Newton and L-BFGS	*Oct 31*	Fast/fancy algorithms for unconstrained optimization [NW05]: inexact/matrix-free Newon (Newton-CG), non-linear least-squares and Gauss-Newton, Levenberg-Marquardt, active-set methods	*Nov 2*	Constrained optimization [NW05]: penalty methods, augmented Lagrangian
11	*Nov 5*	derivatives; some thms from [BC11], [Ber99]	*Nov 14*	derivatives, automatic differentiation [NW05]	*Nov 16*	adjoint-state method
12	*Nov 12*	Newton's method, self-concordant [BV04 ch 9]	*Nov 21*	Newton's method, self-concordant [BV04 ch 9]	*Nov 23*	Newton for equality constraints [BV04 ch 10], interior-point methods [BV04 ch 11]
13	*Nov 19*	Thanksgiving (no class)	*Nov 21*	Thanksgiving (no class)	*Nov 23*	Thanksgiving (no class)
14	*Nov 26*	interior-point methods [BV04 ch 11]	*Nov 28*	First order methods: proximal pt, subgradient descent, conditional gradient aka Frank-Wolfe	*Nov 30*	First order methods: ADMM [Boyd10], Douglas-Rachford [BC17], [CP11]
15	*Dec 3*	Primal-dual method [Con13] [CBS14][CCPV14][ChPo11]	*Dec 5*	Simplex method [NW05]	*Dec 7*	Complexity of LP and Simplex [Nem16], smoothed analysis, integer linear programming [Van08]; LP in fixed dimension [DMW97]
16	*Dec 10*	STUDENT PRESENTATIONS	*Dec 12*	STUDENT PRESENTATIONS	*Dec 14*	STUDENT PRESENTATIONS

References (books)

[BV04]	S. Boyd and L. Vandenberghe, "Convex Optimization" (Cambridge U. Press, 2004). Free electronic version at www.stanford.edu/~boyd/cvxbook/.
[NW05]	J. Nocedal and S. Wright, "Numerical Optimization" (Springer, 2005). We have free electronic access at SpringerLink https://link.springer.com/book/10.1007%2F978-0-387-40065-5
[Nem16]	A. Nemirovski, Introduction to Linear Optimization, lecture notes. http://www2.isye.gatech.edu/~nemirovs/OPTI_LectureNotes2016.pdf
[Van08]	R. Vanderbei, "Linear Programming." (2008) Free download at Vanderbei's website and also via SpringerLink. http://www.princeton.edu/~rvdb/LPbook/
[BC11]	H. Bauschke and P. Combettes, "Convex Analysis and Monotone Operator Theory in Hilbert Spaces", 1st ed, Springer 2011, available electronically via SpringerLink https://link.springer.com/book/10.1007%2F978-1-4419-9467-7
[BC17]	H. Bauschke and P. Combettes, "Convex Analysis and Monotone Operator Theory in Hilbert Spaces", 2nd ed, Springer 2017, available electronically via SpringerLink https://link.springer.com/book/10.1007/978-3-319-48311-5
[Ber99]	D. Bertsekas, "Nonlinear Programming", 2nd ed, Athena Scientific, 1999.
[Ber16]	D. Bertsekas, "Nonlinear Programming", 3rd ed, Athena Scientific, 2016. See http://www.athenasc.com/nonlinbook.html
[Nes04]	Y. Nesterov, "Introductory Lectures on Convex Optimization" (2004); http://www.springer.com/us/book/9781402075537

References (papers)

[Boyd10]	"Distributed Optimization and Statistical Learning via the Alternating Direction Method of Multipliers" by S. Boyd, N. Parikh, E. Chu, B. Peleato, and J. Eckstein (2010); http://web.stanford.edu/~boyd/papers/pdf/admm_distr_stats.pdf
[CP11]	P. L. Combettes and J.-C. Pesquet, "Proximal splitting methods in signal processing," 2011; http://www4.ncsu.edu/~pcombet/prox.pdf
[Con13]	Laurent Condat "A primal-dual splitting method for convex optimization involving Lipschitzian, proximable and linear composite terms", 2011 (J. Optim. Theory and Appl. 2013). https://www.gipsa-lab.grenoble-inp.fr/~laurent.condat/publis/Condat-optim-JOTA-2013.pdf
[CBS14]	"Convex Optimization for Big Data: Scalable, randomized, and parallel algorithms for big data analytics", Volkan Cevher, Stephen Becker, Mark Schmidt, IEEE Signal Processing Magazine, vol. 31, no. 5, 2014; http://dx.doi.org/10.1109/MSP.2014.2329397
[CCPV14]	"A forward-backward view of some primal-dual optimization methods in image recovery", Patrick L. Combettes, Laurent Condat, Jean-Christophe Pesquet, Bang Cong Vu (2014); https://arxiv.org/abs/1406.5439
[ChPo11]	"A first-order primal-dual algorithm for convex problems with applications to imaging", A Chambolle, T Pock (2011); https://hal.archives-ouvertes.fr/hal-00490826/document
[Luc10]	"What Shape Is Your Conjugate? A Survey of Computational Convex Analysis and Its Applications", Yves Lucet, SIAM Review, 52(3) 2010; https://doi.org/10.1137/100788458
[CW05]	"Signal recovery by proximal forward-backward splitting", PL Combettes, VR Wajs - Multiscale Modeling & Simulation, 2005; http://www4.ncsu.edu/~pcombet/mms1.pdf
[Van16]	EE236C class, L. Vandenberghe, 2016; http://www.seas.ucla.edu/~vandenbe/236C/lectures/gradient.pdf
[Ben95]	A. Benjamin, Sensible rules for remembering duals. SIAM Review (37)1 1995.
[BT10]	A. Beck and M. Teboulle, "Gradient-Based Algorithms with Applications in Signal Recovery Problems" (2010); http://www.math.tau.ac.il/~teboulle/papers/gradient_chapter.pdf
[DMW97]	M. Dyer, N. Megiddo, E. Welzl, "Linear programming" (chapter in Handbook of Discrete and Comp. Geometry, 1997) http://www.inf.ethz.ch/personal/emo/PublFiles/LpSurvey03.pdf
[Dual]	"Please explain intuition behind dual problem", https://math.stackexchange.com/q/223235/98783