Research Course on Approximation Algorithms

(A) Topics
(1) Introduction to (i) NP completeness, strong NP completeness; (ii) Linear programs -- strong and weak duality; (iii) approximation algorithms; (iv) basic ideas from probability -- linearity of expectations, moments, tail inequalities, etc.
(2) Greedy algorithms and local search -- k-center problem; TSP; minimum degree spanning tree;
(3) Rounding and Dynamic Programming -- knapsack; bin-packing; scheduling jobs on identical parallel machines
(4) Deterministic rounding of linear programs -- solving large linear programs in polynomial time via ellipsoid method; prize collecting Steiner tree; uncapacitated facility location
(5) Random Sampling and randomized rounding of linear programs -- derandomization; linear and non-linear randomized rounding; integrality gap; MAX-CUT, MAX-SAT; prize collecting Steiner tree; uncapacitated facility location; integer multicommodity flows
(6) Semidefinite programming -- introduction; randomized rounding in semidefinite programming; finding large cuts; approximating quadratic programs
(7) Primal Dual method -- introduction; feedback vertex set; shortest s-t path; Lagrangean relaxation and k-median problem
(8) Cuts and metrics -- multiway cut, multiple cut, balanced cut, probabilistic approximation of metrics by tree metrics; spreading metrics, tree metrics and linear arrangement
(9) Iterative methods -- generalized assignment problem, discrepancy based methods, etc.
(10) Geometric approximation algorithms -- well separated pair decomposition; VC dimension, epsilon-net, epsilon sampling, discrepancy; random partition via shifting; Euclidean TSP; approximate nearest neighbor search; core-sets
(11) Hardness of approximation -- approximation preserving reduction; use of PCP; unique games conjecture

(B) Pre-requisites/Co-requisites, if any: Basic course in discrete mathematics and algorithms is an essential prerequisite. A course in discrete probability is desirable.

(C) Number of lectures per week: 2 double lectures, i.e. 4 hours per week

(D) Grading policy: As this is a research course; a major portion of the marks would be allotted to reading, understanding and delivering seminars on classic and current research papers. Depending on the paper content, it would be 2~4 papers in the semesters. Apart from that, there will be exams/exercises/term papers. There will be commensurate weightage on both.

(E) List of references:
1. Vijay V. Vazirani: Approximation Algorithms, Springer-Verlag, Berlin, 2006
2. David P. Williamson and David B. Shmoys: The Design of Approximation Algorithms, Cambridge University Press, 2011.
3. Sariel Har-Peled: Geometric Approximation Algorithms, American Mathematical Society, 2011.