

Birla Institute of Technology and Science, Pilani
First Semester 2021-2022
Course Handout Part II

Date: 20/08/2021

In addition to the Part-I (General Handout) for all courses appended to the timetable, this portion gives further specific details regarding the course.

Course No. : CS F441
Course Title : SEL TOPICS FROM COMP SC (Approximation Algorithms)
Instructor-in-Charge: Dr. Manjanna B

1. Scope and Objective:

The objective of this course is to introduce each individual student to the area of approximation algorithms that is aimed at giving provable guarantees on the performances of heuristics for hard problems. The course will present general techniques that underlie these algorithms.

Since many important problems are known to be NP-complete, recent research in algorithms has sought to develop heuristics for these problems that have provable guarantees on their performance. In particular, given an instance of an NP-hard optimization problem, a C -approximation algorithm outputs a solution that has cost at most C times the cost of the optimal solution. This has been complemented by research on the "hardness of approximation" for such problems: this involves showing values of D such that obtaining a D -approximation is provably hard (under complexity-theoretic assumptions).

In this course,

- We will learn about techniques to design and prove approximability of combinatorial optimization problems.
- We will learn about classic and recent advances in approximation algorithms.
- We will learn about proving inapproximability of approximation algorithms under complexity hypotheses.

Towards the end of the course, the following are the topics students will know:

Techniques: greedy, local search and other combinatorial techniques, dynamic programming and approximation schemes, randomized techniques, LP based techniques – randomized rounding, primal-dual, iterative rounding, local ratio, dual-fitting, Semi-definite programming based techniques. Geometric Approximation: Dudley's theorem and applications, well-separated pair decompositions and geometric spanners, VC dimension, epsilon-nets and epsilon-approximations, Polynomial Time Approximation Schemes via Shifting Strategy of Hochbaum and Maass, and Separators.

Problems: Metric-TSP, knapsack, bin packing, multiprocessor scheduling, steiner trees, steiner forests, vertex cover, set cover and generalizations, k-center, k-median, facility location, max-cut, multiway cut, k-cut, art gallery, closest pair, geometric packing, covering and other geometric problems.

Hardness of approximation: approximation preserving reductions, some simple proofs and statement of the PCP theorem.

2. Text Book:

T1: The design of Approximation Algorithms, by David Williamson and David Shmoys, Cambridge University Press, 2011.

3. Reference Books:

R1. Approximation Algorithms by Vijay Vazirani, Springer-Verlag, Berlin, 2001.

R2. Geometric Approximation Algorithms by Sarel Har-Peled, AMS Series in Mathematical Surveys and Monographs, 2011.

AR. Related research papers and Additional reading assigned by the Instructor.

4. Course Plan

No. of Lectures	Learning objectives	Topics to be covered	Chapter in the Textbook
1-3	Introduction	What are approximation algorithms. Why do we need them, Absolute/additive approximation, approximation ratio.	T1: Ch 1 R1: Ch 1
4– 8	To learn greedy tech: Metric-TSP	Nearest addition, Christofides' algorithm, Recent breakthrough.	T1: Ch 2
9– 12	To develop PTAS for Knapsack,	Dynamic programming,	T1: Ch 3
13-16	To solve Bin packing, multiprocessor scheduling problems	Rounding data, Dynamic programming.	T1-Ch 3,4,5 R1
17-19	To introduce LP based appx alg: Steiner trees, Steiner forests,	LP, Randomized rounding.	T1-Ch 4,5 R1
20-22	To learn LP based appx alg: Vertex cover,	Greedy, LP.	T1 – Ch 1
23-25	To learn primal dual tech for designing for appx alg: Set cover and generalizations	Greedy, LP, Primal-dual method.	T1 – Ch 2,7
26-29	To design appx alg for classical locations problems: k-center and k-median,	Greedy, local search.	T1-Ch , 2, 6, 7
30-33	To study appx alg for Facility location problems	Deterministic rounding, randomized rounding.	T1: Ch 4, 5,12 R1, AR
34-38	To study approximability of max-cut, multiway cut, k-cut problems	SDP, LP rounding.	T1 – Ch 6, 8
39-42	To introduce techniques for geometric apprx: Art gallery, geometric covering and packing problems	Epsilon-net, VC dimension.	R2: 1, 3, 4, 5, 6, AR

5. Evaluation Scheme:

Sr. No.	Component	Duration	Weightage (%)	Date & Time	Nature of Component
1.	Quiz 1	40 min.	10%	To be announced (before midsem)	Open Book
2.	Quiz 2	40 min.	10%	To be announced	Open Book
3.	Research Paper Presentation		15 %	To be announced	
3	Midterm Exam	1.5 hrs	25%	21/10/2021 3.30 -5.00PM	Open Book
4.	Comprehensive Exam	2 hrs.	40%	21/12 FN	Open Book

Note: 40% of the evaluation to be completed by midsem grading.

6. **Consultation hours:** To be announced in the class.

7. Make-up Policy:

Prior Permission of the Instructor-in-Charge is usually required to take a make-up for a test.
A make-up test shall be granted only in genuine cases on justifiable grounds.

8. **Notices:** Notice regarding the course will be displayed on the CMS.

9. **Academic Honesty and Integrity Policy:** Academic honesty and integrity are to be maintained by all the students throughout the semester and no type of academic dishonesty is acceptable.

Instructor in Charge