

GIAN Course 2025

Sparse graphs: treewidth, planarity, bounded expansion

Among the most successful research approaches in graph theory and graph algorithms have been the study of sparse graphs. Among those, planar graphs have been historically one of the most studied graph classes, due to its numerous real-world applications, dating back to works of Euler and the celebrated four-color conjecture/theorem. Another type of sparse graphs are graphs of bounded treewidth, that have enormous applications not only in structural graph theory, but also in providing efficient algorithms for many computational problems on graphs and more generally, any kind of discrete structure, due to the celebrated Courcelle's theorem.

However, planar graphs and graphs of bounded treewidth form (seemingly) somewhat orthogonal graph classes, since planar graphs can have arbitrarily large treewidth and graphs of treewidth 3 may be non-planar. A common generalization of these classes has been studied, under the umbrella of graph minors, leading to the deep and complex theory of minor-closed graph classes by Robertson and Seymour.

In the last 20 years, these efforts have been further extended which led to a comprehensive theory of sparse graphs, especially, thanks to the efforts of Nešetřil and Ossona de Mendez, with the publication of the influential book, titled "Sparsity", on the topic in 2012. In this theory, many properties of minor-closed graph classes are generalized through the concept of shallow minors, and the definition of graph classes of bounded expansion.

In this course, we will start by exposing fundamental structural properties of graphs of bounded treewidth, planar graphs, and show how to generalize these properties to graph classes of bounded expansion.

Scientific area: structural graph theory and its applications to algorithms.

Objectives:

- Teaching the fundamental properties of graph classes of bounded treewidth, planar graphs, and graphs of bounded expansion.
- Illustrate the usefulness of these graph classes by concrete algorithmic applications.
- Give the students the opportunity to apply the exposed techniques during the tutorials.
- Give perspectives to more general graph classes and graph parameters: nowhere dense graphs, and structured classes of dense graphs (*via* e.g. twin-width and clique-width).

Structure	The course is to be conducted in a completely offline mode with 24 hours of lectures and 24 hours of tutorial. Further details can be found on the website: https://sites.google.com/view/giansparsegraph/home
Important dates	Last date of Registration: 31 January 2025 (priority given to those who register sooner) Notification of acceptance: on or before 7 February 2025 Dates for the workshop: 24 February (Monday)-7 March (Friday) 2025 (breaks on 1 March (Saturday) & 2 March (Sunday) 2025)
Participation	<ul style="list-style-type: none"> ▪ The primary target participants are Ph.D. students from Mathematics or Computer Science or related departments whose research interest lies in graph theory and graph algorithms. This course may lead to research projects and collaborations. ▪ Advanced Masters (M.Sc./M.Tech. or equivalent) students with a particular interest and background in graph theory and algorithms are also encouraged to participate. ▪ Interested faculty members from reputed academic institutions and technical institutions are also regarded as potential participants. <p>Note: <u>The number of student participants will be limited to 50.</u></p>
Fees	<p>The participation fees for taking the course are as follows:</p> <p>Students/Postdocs: 2000 INR (shared hostel accommodation included) Students/Postdocs: 1000 INR (accommodation not included) Faculty/Industry professional: 2500 INR (accommodation not included)</p> <p>Food can be availed at IIT Dharwad on a payment basis (details to be updated in the website).</p> <p>Note: <u>There is no central registration on the GIAN portal (gian.iith.ac.in); registration will be managed directly by the hosting institute.</u></p>
Registration link	<p>Please register using the following link https://forms.gle/4MaACrHDhYwQ29jC9</p> <p>Note: <u>After you register, selected candidates will be notified by email, and upon payment of the registration fees their candidature will be confirmed. Payment related details will be included in the selection notification email.</u></p>
Website	https://sites.google.com/view/giansparsegraph/home (find syllabus and other details here)
Important notes	<ul style="list-style-type: none"> • A certificate of participation will be given to all. • An examination will be conducted on the last day of the workshop and qualified candidates will be provided a grade sheet. • For PhD students enrolled in Indian institutes, this course is equivalent to 2 credits of coursework. This is valid only for those candidates who registers and pass the examination.

The Course Instructors



Prof. Florent Foucaud is an associate professor (maître de conférences) at the Université Clermont Auvergne, France. His research is in graph algorithms and graph theory. Some of his favorite graph problems include graph identification problems (in particular, identifying codes and metric dimension), graph homomorphisms, graph domination or metric-based covering and packing problems. He is interested both in structural aspects and the algorithmic complexity of such graph problems.

Homepage: <https://perso.limos.fr/ffoucaud/>

Prof. Sagnik Sen is an Assistant Professor at IIT Dharwad, India and at present holds the position of the Head of the Department of Mathematics. His primary research interest is in graph homomorphisms and colorings. He analyses the structural aspects of graph homomorphisms, and studies coloring as a special case of it. He particularly focuses on graphs having different types of adjacency rules, and therefore, has works on homomorphisms of oriented graphs, signed graphs, (n,m) -graphs, etc. He has worked on a wide range of graph theory topics such as: algebraic graph theory, radio labeling, combinatorial games, graph distance related parameters, geometric graphs, graph modification problems, etc.

Homepage: <https://homepages.iitdh.ac.in/~sen/>

Course Co-ordinator

Prof. Sagnik Sen

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Registration link:

<https://forms.gle/4MaACrHDhYwQ29jC9>

Website link:

<https://sites.google.com/view/giansparse/graph/home>

Register quickly to get preference!