

MA691 – Spectral Graph Theory
(2026 Autumn semester)

Instructor: Projesh Nath Choudhury

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Google classroom code: TBA

Course website: http://projesh.people.iitgn.ac.in/Teaching/MA691_2026.html

Office: AB-6/356

Office hours: TBA

Course goals: This course is an introduction to spectral graph theory, developing essential tools for applying algebraic and spectral techniques in the study of graphs.

PRE-REQUISITES

Basic knowledge of graph theory and a strong foundation of linear algebra.

LIST OF TOPICS

(The selection of topics is variable depending on time constraints.)

- (1) Review of basic concepts of graph theory. Incidence Matrix: Rank, Minors, 0–1 Incidence matrix, Matchings in bipartite graphs.
- (2) Adjacency Matrix: Eigenvalues of some graphs, Determinant, Bounds, Energy of a graph, inverse of trees. Perron–Frobenius theory: Adjacency algebra of a regular graph, Complement and line graph of a regular graph, Strongly regular graphs and friendship theorem, Graphs with maximum energy, Hoffman’s ratio bound, Cvetkovic’s inertia bounds, Page–Rank algorithm.
- (3) Laplacian Matrix: Basic properties, Matrix-tree theorem, Bounds for Laplacian spectral radius, Edge-Laplacian of a tree, Algebraic Connectivity, Classification of trees, Monotonicity properties of Fiedler vector, Bounds for algebraic connectivity. Fundamental cycles and fundamental cuts.
- (4) Expander graphs: Basic properties, Ramanujan graphs
- (5) Distance Matrix of a Tree, Distance matrix of a graph, Distance matrix and Laplacian of a tree, Eigenvalues of the distance matrix of a tree. Stable polynomials: characterizations and connections.

SUGGESTED BOOKS AND REFERENCES

- (1) R.B. Bapat. *Graphs and Matrices*. Springer, 2014.
- (2) E. Brouwer and W. H. Haemmer. *Spectra of Graphs*. Springer, 2012.
- (3) C. Godsil and G. Royale. *Algebraic Graph Theory*. Springer, 2001.

LECTURES AND TUTORIALS

- **Lectures:** TBA
- **Tutorials:** TBA

ASSIGNMENT

Assignment will be given fortnightly – posted on the course webpage. Discussing in a group is allowed and encouraged; however, each student should hand in their independently written solutions, written in their own words. Mere copying of others’ work is strictly prohibited.

POLICY FOR EVALUATION

- **Mid-sem exam:** 25%
- **End-sem exam:** 25%
- **Assignments+presentations:** 40%
- **Attendance:** 10%

ATTENDANCE POLICY

Class participation will help you in staying on track and developing a deeper understanding and interest in the subject. As a result, attendance at lectures will be recorded. The following is the policy for the marks based on the percentage in attendance:

% in Attendance	Marks
Above or equal to 80	10
60 to less than 80	5
Below 60	0

*If you miss a class due to medical reasons and want to record attendance for that day, you need to provide a medical certificate from the institute health center doctor stating that you are not fit to appear for the class on that day.

HONOR CODE

Students are expected to follow the Institute Honor Code at all times. Any suspected/alleged violations of the Honor Code will be investigated and may lead to disciplinary action, as per Institute policy.

GRADING POLICY

Relative grading policy will be followed.