MTH 203: INTRODUCTION TO GROUPS AND SYMMETRY

SEMESTER 1, 2019-2020

Course Information

- **Lectures Time and Venue:** Tue, Thu 8-8.55 AM, Fri 11-11.55 AM in L1
- **Instructor:** Dr. Sanjay Kumar Singh
  Office: 210, Academic Building 1
  Webpage: http://home.iiserb.ac.in/∼sanjayks
  Office Hour: Monday $5.00 - 6.00$ PM or by appointment.
  Email: sanjayks at iiserb.ac.in
- **Tutorial time:** Wed 6-7 PM
- **Tutorial Class Venue and Group:**
  (1) L-6, Roll No. 18001 to 18067 (Riju Basak)
  (2) L-7, Roll No. 18070 to 18142 (Makarand Sarnobat)
  (3) L-8, Roll No. 18143 to 18234 (Swapnil Tripathi)
  (4) L-9, Roll No. 18235 to 18314 (Soumya, Amir Hossain)
  (5) L-10, Roll No. 18318 to 18384 (Neeraj Dhanwani)
  (6) L-11, Roll No. 18386 to 18414 and Backlog(repeat) (Shailesh Tiwari)
- **Tutors:**
  (1) Riju Basak (L-6)
  Office: 110, AB-1A
  Office hours: Friday, 6-7 PM
  Email: riju.basak at iiserb.ac.in
  (2) Dr. Makarand Sarnobat (L-7)
  Office: 303, AB-1
  Office hours: Friday 4-5 PM.
  Email: makarands at iiserb.ac.in
  (3) Swapnil Tripathi (L-8)
  Office: 103, AB-1A
  Office hours: Friday, 5-6 PM
  Email: swapnil93 at iiserb.ac.in
  (4) Dr. Soumya Dey (L-9)
  Office: 207, AB-1
  Office hours: Monday, 3-4 PM
  Email: soumyadey at iiserb.ac.in
  (5) Md Amir Hossain (L-9)
  Office: AB-1A
  Office hours: Saturday, 5-6 PM
  Email: mdamir18 at iiserb.ac.in

(6) Neeraj Kumar Dhanwani (L-10)
Office: AB-1A
Office hours: Tuesday, 5-6 PM
Email: nkd9335 at iiserb.ac.in
(7) Dr. Shailesh Tiwari (L-11)
Office: 205, AB-1
Office hours: Tuesday, 4-5 PM
Email: sktiwari at iiserb.ac.in
(8) Dr. Jyoti Prakash Saha (Mentor)
Office: 206, AB-1
Office hours: Saturday 9-10 AM
Email: jpsaha at iiserb.ac.in

Learning Objectives: Symmetries in nature are a source of curiosity for various scientific fields. Often these are the reasons of stability of various structures and patterns formed in nature. The study of symmetries is naturally intertwined with the concept of transformations of the corresponding objects. Group theory arose in nineteenth century to formalize these ideas. This course is aimed at building these ideas as we explicitly try to understand the nature of symmetries that occur in each individual case and compute these in details.

Course Contents.

- Examples of symmetries: Symmetries of equilateral triangle and square; translations, rotations and reflections in the Euclidean plane.
- Definition of a group, subgroup, abelian group, group $\mathbb{Z}$ of integers, statement of division algorithm, description of all subgroups of $\mathbb{Z}$.
- Equivalence relations, group of congruence classes $\mathbb{Z}_n$, order of an element in a group, definition of cyclic group, cyclicity of groups of prime order, group of units in $\mathbb{Z}_n$.
- Definition of a homomorphism and normal subgroup, kernel and image of a homomorphism, quotient group, isomorphism theorems (statement and applications).
- Permutations of a finite set, permutation group S_n, cycle notation, length of a cycle, transpositions, decomposing a permutations as a product of transpositions, parity of a permutation, alternating group A_n as normal subgroup, conjugacy in permutation groups, generating sets of S_n and A_n.
- Groups of real and complex matrices: general linear groups, determinant of a matrix as a group homomorphism, special linear groups, complex matrices as real matrix, orthogonal and special orthogonal groups, unitary and special unitary groups.
- Two dimensional symmetries: group of symmetries of geometric objects in Euclidean spaces, dihedral group as the group of symmetries of a regular polygon, isometries of the Euclidean plane, a detailed account of the classification of isometries: translations, rotations, reflections, glide reflections; wallpaper symmetries, finite subgroups of $SO(2)$.

- Three dimensional symmetries: platonic solids and their dual, symmetries of a tetrahedron, symmetries of a cube and octahedron, symmetries of icosahedron and dodecahedron, classification of finite subgroups of $SO(3)$.

$$http://acad.iiserb.ac.in/pdf/mth.pdf$$

Reference books:

- Ramji Lal, Algebra 1 (Groups, Rings, Fields and Arithmetic) Infosys Science Foundation Series in Mathematical Sciences Springer.
- Abstract algebra, Dummit, David S; Foote, Richard M.
- Topics in Algebra, I.N. Herstein.
- Contemporary Abstract Algebra, Joseph A. Gallian.
- Abstract Algebra: an Introduction, S. Hungerford.
- A First Course in Abstract Algebra, J.B. Fraleigh.
- Basic Algebra: Groups, Rings, and Fields, P.M. Cohn.
- Undergraduate Algebra, Serge lang.
- University Algebra, N.S. Gopalakrishan.
- Algebra (2nd Edition), M. Artin, Pearson, 2010.
- Groups and Symmetry, Mark A. Armstrong, Springer, 1997.
- A First Course in Abstract Algebra, Joseph J. Rotman, Pearson, 2005.
- Matrix groups for Undergraduates, Kristopher Tapp, AMS, 2005.
- Symmetry: A Mathematical Exploration, Kristopher Tapp, Springer, 2012.
- A course in the theory of groups, Robinson, Derek J. S.
- Bourbaki, N., Elements of Mathematics; Algebra I; Chapters 1-3, SpringerVerlag, New York, 1989.
- van der Waerden, B. L.,Modern Algebra, 4th ed., Ungar, New York, 1966.
- McCoy, N. H., and Janusz, G. J., Introduction to Modern Algebra, 5th ed., Wm. C. Brown Publishers, Dubuque, Iowa, 1992.
- Isaacs, I. M., Algebra, A Graduate Course, Brooks/Cole Publishing, Pacific Grove, 1994.
- Jacobson, N., Basic Algebra I, Freeman, San Francisco, 1974.

Reference Online Notes:

- Online notes: http://www.math.columbia.edu/ bayer/F03/symmetry/
- Online notes: https://neil-strickland.staff.shef.ac.uk/courses/groups/
- Online Notes on Groups and Symmetry, Andrew Baker http://www.maths.gla.ac.uk/ ajb/dvi-ps/2q-notes.pdf

Grading Policy:

- Surprise Quizzes and Assignment: 10%
- Quizzes: 10%
- Mid Semester Exam: 30%
- Final Exam: 50%

Assignment. There will be 8 assignments in this course. It will be assigned (posted online on course web page) on Wednesday, and will be submitted and discussed on the-following Wednesday during tutorial.

Quiz: There will be two announced quizzes. There will be some surprise quizess specially in tutorial classes. Proposed dates for quizzes are as follows:

- Quiz 1: 28/08/2019.
- Quiz 2: 30/10/2019.

Home work and class exercise. In every class you will get some home work which you don't need to submit. You can discuss it in office hours.

Problems in your examination will be based on assignments, home works and class exercises.

***.** In case of any further questions regarding the course, please send me an email.