Syllabus
Applied Algebra
Spring 15

(A) Instructor: Prof. Shamgar Gurevich.

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Time and Location: Tue-Thu 1-2:15pm, Room VV901.

Office Hours: Tue 10:45-11:45, 14:15-15:15 (or by appointment).

(B) Grader: Mr. David Dynerman.

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(B') Computing: Dr. Steven Goldstein.

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Office Hours: by appointment.

(C) Texts: Some references will be given in class.

(D) Content: We hope to cover parts of:

1. **Detecting Molecular Symmetry:**
   (a) Motivation.
   (b) The group $SO(3)$ of proper rotations of 3D space.
   (c) Platonic solids, molecules, and their symmetry.
   (d) Finite subgroups of $SO(3)$ and Klein's theorem.
   (e) Cryo electron microscopy (Cryo-EM). Math model.
   (f) Flow chart algorithm.
   (g) Programming, implementation, and signal processing.
2. **Wireless Communication for Static and Moving Users:**
   (a) Motivation.
   (b) Physical wireless channel. Math model.
   (c) Digital wireless channel. Math Model.
   (d) Static users. OFDM method.
   (e) Moving users. Theta method.
   (f) Statistical performance. Capacity.
   (g) Programming, implementation, and signal processing.
3. **Delay-Doppler Channel Estimation**
   (a) Motivation. Radar Detection.
   (b) Physical wireless channel. Math model.

(c) Digital wireless channel. Math Model.

(d) Pseudo-random method. Numerics. Complexity and Performance.

(e) Fast Fourier Transform (FFT) and Spars Fast Fourier Transform (SFFT).

(f) Incidence method. Numerics. Complexity and Performance.

4. **Random Walk on Finite Groups**

(a) Motivation.

(b) Riffle shuffle card shuffling (RSCS). Math model. Problem formulation.

(c) Numerical verification. The cut-off phenomenon.

(d) Representations of the symmetric group S_n. Frobenius Character Formula.

(e) Diaconis–Bayer Theorem. Solution to RSCS problem.

(f) Random walk (RW) on S_n using transpositions. Problem formulation.

(g) Numerical verification. Cut-off.

(h) Diaconis–Shahshahani's 'Upper Bound Lemma'. Solution to the S_n RW problem.

(i) Random walk on the special linear group $SL_2(\mathbb{F}_q)$ using transvections. Problem formulation.

(j) Numerical verification. Cut-off.

(k) Representations of $SL_2(\mathbb{F}_q)$. Theta. Bounds on Characters. Solution to the $SL_2(\mathbb{F}_q)$ RW problem.

(E) Grading: There will be homework assignments, and a final project with presentation. The grade distribution will be computed as follows:

HW	34%
Progress	33%
Project	33%

For grade above 90 you will get A, For grades above 80 you get AB, etc.

(F) Prerequisite: Linear Algebra on the level of Math 340 or 341. You don't need to known any programming language.

Good Luck!