Syllabus for PHYSICS 590 II (Spring 2017)
GROUP THEORY AND SYMMETRIES IN PHYSICS

Instructor: Dr. Bhupal Dev (bdev@wustl.edu)

Lecture Hours: 3 hours per week (Tuesdays and Thursdays 1.00-2.30 PM), 14 weeks total.

Office Hours: Wednesdays 2.00-4.00 PM or by appointment.

Homework: Problem sets will be handed out in class (and posted online) every Thursday. These are expected to be solved and returned before the following Thursday 1 PM.

Exams: A mid-term (just before Spring Break) and a final (end of April). Both will be take-home exams.

Grading: 50% homework, 20% mid-term and 30% final.

Textbook: I will mostly follow *Group Theory: A Physicist's Survey* by P. Ramond (Cambridge University Press, 2010) and *Group Theory in a Nutshell for Physicists* by A. Zee (Princeton University Press, 2016). For some specific topics, I will also use *Lie Algebras in Particle Physics* by H. Georgi (Westview Press, 1999). In addition, I might occasionally refer to other books and/or publicly available lecture notes/reviews (will give you the references, when needed).

Schedule: Here is a tentative list of topics we plan to cover (might vary depending on the time and class interest):

Week 1 [1/17, 1/19]: General properties of groups (definition, subgroups, Lagrange's theorem, quotient group, isomorphism, cojugate); finite groups; multiplication table.

Week 2 [1/24, 1/26]: Representation theory; Schur's lemma; orthogonality theorem; conjugacy class, character table; direct sums and tensor products; Young tableaux.

Week 3 [1/31, 2/2]: Classification of finite groups; examples and applications in real life.

Week 4 [2/7, 2/9]: Examples of continuous groups from elementary physics: $SO(N)$, $SU(N)$.

Week 5 [2/14, 2/16]: Lie groups; Jacobi identity; Cartan-Weyl basis; classification of simple Lie algebras.

Week 6 [2/21, 2/23]: Roots and weights; Dynkin diagrams.

Week 7 [2/28, 3/2]: Representation theory of Lie algebra; Casimir operators; Clebsch-Gordan coefficients; Wigner-Eckart theorem.

Week 8 [3/7, 3/9]: Spinor representations; Clifford algebra; Dirac matrices.

Spring Break [3/12-3/18].

Week 9 [3/21, 3/23]: Charge conjugation (C) symmetry; Weyl, Dirac and Majorana spinors; some physics applications (Dirac equation, Kitaev chain).

Week 10 [3/28, 3/30]: Space-time symmetries: parity (P) and time-reversal (T), CPT theorem, matter-antimatter asymmetry; translation and rotation, Lorentz and Poincaré groups.

Week 11 [4/4, 4/6]: Conformal symmetry, supersymmetry and superalgebra.

Week 12 [4/11, 4/13]: Gauge symmetries: Abelian and non-Abelian; symmetries of the Standard Model.

Week 13 [4/18, 4/20]: Grand Unification: $SU(5)$, $SO(10)$ and more.

Week 14 [4/25, 4/27]: Exceptional groups; left-over topics and/or revision.