**Syllabus for PHYSICS 543 (Spring 2019)**

**GROUP THEORY AND SYMMETRIES IN PHYSICS**

**Instructor:** Prof. Bhupal Dev (bdev@wustl.edu)

**Lecture Hours:** 3 hours per week (M-W-F 2-3 pm, Crow 205), 14 weeks total.

**Office Hours:** Fridays 3-5 pm or by appointment. Office: Compton 373.

**Course Website:** `https://web.physics.wustl.edu/bdev/PHYS_543.htm`

**Weekly Homework:** Problem sets will be posted online *every Friday* after class. The written homework should be submitted by the *following Friday 2.10 pm* (before the class starts). No late homework will be accepted. Instructor solutions will be made available online after the due date.

**Exams:** One mid-term (on 6th March, 2-3 pm) and one final (on 3rd May, 8-10 am). Both will be in-class (but open-book) exams.

**Grading:** 37% homework, 3% class participation, 20% mid-term, 40% final.

**Textbook:** We will mostly follow A. Zee, *Group Theory in a Nutshell for Physicists*, Princeton University Press (2016). For some topics, might occasionally refer to P. Ramond, *Group Theory: A Physicist's Survey*, Cambridge University Press (2010) and H. Georgi, *Lie Algebras in Particle Physics*, Westview Press (1999).

**Schedule:** Here is a tentative list of topics we plan to cover.

*Week 1*: Symmetry operations, Group axioms, subgroup, Lagrange's theorem, Direct product, multiplication table, homomorphism and isomorphism, finite groups, permutation group.

*Week 2*: Equivalence class, Invariant subgroup, Simple group, Coset, Quotient group, Derived subgroup.

*Week 3*: Representation theory, Schur's lemma, Orthogonality theorem, Conjugacy class, Character table, Direct sum, Tensor product, Young tableaux.

*Week 4*: Real, pseudoreal and complex representations, Harmonic motion and zero modes.

*Week 5*: Continuous groups, Lie algebra, Jacobi identity, Representation theory of Lie algebra, Adjoint representation.

*Week 6*: $SO(N)$ Lie algebra, Ladder operators, Casimir invariants, Spherical harmonics, Clebsch-Gordan decomposition, Wigner-Eckart theorem.

*Week 7*: $SU(N)$ Lie algebra, Local isomorphism between $SU(2)$ and $SO(3)$, Electron spin and Kramer's degeneracy.

*Week 8*: Pauli matrices, Gell-Mann matrices, Structure constants.

*Spring Break*

*Week 9*: Integration over continuous groups, Topology, Group manifold.

*Week 10*: Isospin, Eightfold way, Meson and Baryon masses.

*Week 11*: Cartan-Weyl basis, Classification of simple Lie algebras, Roots and weights, Dynkin diagrams.

*Week 12*: Spinor representations, Clifford algebra, Dirac matrices, Majorana and Weyl fermions.

*Week 13*: Lorentz and Poincaré groups.

*Week 14*: Conformal algebra, Supersymmetry and superalgebra.