**Syllabus for PHYSICS 474 (Spring 2020)**

# Introduction to Particle Physics

**Instructor:** Dr. Bhupal Dev (Email: `bdev@wustl.edu`; Phone: 55843; Office: Compton 373)

**Assistant to Instructor (AI)**: Fang Xu (`xufang@wustl.edu`)

**Lecture Hours:** M-W 11.30-12.50, Crow 206.

**Office Hours:** Wednesdays 14.30-15.30 or by appointment.

**Course Website:** `https://web.physics.wustl.edu/bdev/PHYS_474_Spring20.htm`

**Textbook:** *Introduction to Elementary Particles* (2nd edition) by David Griffiths, Wiley-VCH (2010). For further reading (strongly encouraged), see e.g.

1. *Introduction to High Energy Physics* (4th edition) by Donald Perkins, Cambridge University Press (2000).
2. *The Standard Model in a Nutshell* by Dave Goldberg, Princeton University Press (2017).

There are excellent online (free) resources as well, e.g.

3. *Review of Particle Physics* by Particle Data Group, `http://pdg.lbl.gov/`
4. *The Particle Adventure*, `http://www.particleadventure.org/`

**Homeworks:** Weekly Homeworks will be posted on the course website every Monday, and will be due on the following Monday at the beginning of class. Homework problems are designed to often supplement the in-class discussion. *Late homeworks will not be accepted* (exceptions granted *only* by prior arrangement with the instructor and with a valid reason).

**Exams:** There will be two exams: one mid-term and one final. The Mid-term Exam will be on Wednesday, March 4 11.30-12.50 in Crow 206. It will cover materials from Chapters 1-7 (and HW 1-7). The Final Exam will be on Tuesday, May 5, 10.30-12.30 (room TBA). It will cover materials from Chapters 1-10 (and HW 1-13). Both exams are in-class, closed-book. You may bring a single page of A4 size hand-written "equation sheet" (can use both sides) and a non-programmable calculator. *You must attend both exams to pass this course.*

**Grading:** 35% homework, 20% mid-term, 40% final, 5% class attendance and participation (1% bonus for completing Evals). Your letter grade will be based on an absolute scale; there is no curve! (A+: 100-97, A: 96.9-93, A-: 92.9-90; B+: 89.9-87, B: 86.9-83, B-: 82.9-80; C+: 79.9-77, C: 76.9-73, C-: 72.9-70; D+: 69.9-67, D: 66.9-63, D-: 62.9-60; F: 59.9-0)

## Tentative Schedule:

| Date | Topic | Book Chapters | HW Due |
|---|---|---|---|
| M 1/13 | Introduction: Elementary Particles and Interactions | 1 and 2 | |
| W 1/15 | Relativistic Kinematics, Particle Decays and Scatterings | 3 | |
| M 1/20 | **Martin Luther King Holiday - No Class** | | |
| W 1/22 | Symmetries and Conservation Laws, Noether's Theorem, Group Theory | 4.1 | 1 |
| M 1/27 | The $SU(2)$ Group, Isospin Symmetry | 4.2 | 2 |
| W 1/29 | The $SU(3)$ Group, Isospin and Strangeness, Flavor Symmetry | 4.3 | |
| M 2/3 | Discrete Symmetries ($C$, $P$, $T$), $CP$ Violation, CKM Mixing | 4.4 | 3 |
| W 2/5 | Bound States: Positronium, Quarkonium, Mesons and Baryons | 5 | |
| M 2/8 | Fermi Golden Rule, Decay Width, Scattering Cross Section | 6.1-6.2 | 4 |
| W 2/12 | Feynman Diagrams and Rules | 6.3 | |
| M 2/17 | Dirac Equation and Solutions, Antiparticles | 7.1-7.2 | 5 |
| W 2/19 | Bilinear Covariants, Clifford Algebra | 7.3 | |
| M 2/24 | Feynman Rules for QED, Crossing Symmetry | 7.4-7.5 | 6 |
| W 2/26 | Examples of QED processes | 7.6-7.8 | |
| M 3/2 | Loop Corrections, Renormalization | 7.9 | 7 |
| W 3/4 | **Mid-term Exam** | 1-7 | |
| M 3/9 | **Spring Break - No Class** | - | |
| W 3/11 | **Spring Break - No Class** | - | |
| M 3/16 | Electron-Proton Scattering, Form Factors | 8.1-8.2 | 8 |
| W 3/18 | Feynman rules for QCD, Color Factors | 8.3 | |
| M 3/23 | Examples of QCD processes | 8.4-8.5 | 9 |
| W 3/25 | QCD $\beta$ function, Asymptotic Freedom | 8.6 | |
| M 3/30 | Feynman Rules for Weak Interactions | 9.1 | 10 |
| W 4/1 | Weak Decay of Muon, Neutron and Pion | 9.2-9.4 | |
| M 4/6 | Examples of Charged and Neutral Current Processes | 9.5-9.6 | 11 |
| W 4/8 | Electroweak Unification, Weinberg Mixing Angle | 9.7 | |
| M 4/13 | Lagrangian formulation of QFT | 10.1-10.2 | 12 |
| W 4/15 | Local Gauge Invariance, Yang-Mills Theory | 10.3-10.6 | |
| M 4/20 | Spontaneous Symmetry Breaking, Higgs Mechanism, Standard Model | 10.7-10.9 | 13 |
| W 4/22 | **Review for Final Exam** | 1-10 | |
| T 5/5 | **Final Exam** | 1-10 | |