# Syllabus PHYS 442

## Course Description

An introduction to modern theories about the particles and forces that make up this universe, from Rutherford scattering to an "(almost) theory of everything (visible)" known as the standard model of particle physics. We will also learn about production, detection and properties of fundamental particles. Discussion of problems and puzzles related to the standard model, such as why some particles have mass or why gravity is so much weaker than other forces, and solutions to these problems, such as the Higgs boson, supersymmetry, quantum gravity and string theory.

## Text Book

We are using "Introduction to Nuclear and Particle Physics" by A. Das and T. Ferbel.

Solution manual for this book is available in the reserve section of library next to room MTH 0401.

## Topics to be covered in Physics 442

1. Rutherford scattering: Discovery of the nucleus and the foundation of modern nuclear and particle physics.
2. Nuclear Phenomenology: Properties and nomenclature of the new (strong) nuclear force.
3. Nuclear Models: Quantum physics in the nuclear regime (Shell Model) and collective motion of nucleons.
4. Nuclear Radiation: α, β, and γ emission, barrier penetration, and a new weak interaction (neutrinos)
5. Applications of Nuclear Physics: Fission, fusion, radioactive decay and dating.
6. Energy Deposition in Media: Interactions of charged particles, photons, and hadrons in matter.
7. Particle Detection: Ionization, scintillation, Cherenkov light, wire chambers and calorimetry.
8. Particle Accelerators: Electrostatic, resonance, linear, synchronous, and colliding-beam accelerators, phase stability and strong focusing.
9. Properties and Interactions of Elementary Particles in Matter: Forces, hadrons, resonances, strong, weak, and electromagnetic processes, intrinsic spin, other quantum numbers and their violation.
10. Symmetries in Nature: Lagrangian and Hamiltonian formulations, invariance principles, infinitesimal transformations, continuous and local (gauge) symmetries. (With strong-isospin as example.)
11. Discrete Transformations: Parity, time reversal, charge conjugation, and the CPT theorem.
12. Neutral Kaons, Oscillations, and CP Violation: K0 eigenstates of CP, K0S–K0L mixing and regeneration, and violation of CP invariance in particle interactions.
13. Formulation of the Standard Model: Quarks, leptons, gauge bosons, hadrons, weak-isospin and color symmetries, QCD, and symmetry breaking.
14. Confrontation of the Standard Model with Data: Cabibbo angle, GIM mechanism, CKM matrix, Higgs boson and weak mixing angle, and comparisons to data.
15. Beyond the Standard Model: Grand unification, SUSY, and gravity.

## Schedule, Exams, and Grading

Three lectures per week (M, W and F, 2:00–2:50PM), Room 0410 Math. Building

Office hours: Friday 12 -1pm, Room 3123, PSC

1 midterm during one of the class periods in mid **October**: **15%**

**MIDTERM October TBA**

(You will be allowed to bring a copy of DF book to each exam.)

Home work assignments: **40%**

A written 3-page report on one of several topics we will recommend (or you can choose on your own): **20%,**

**Dec. TBA**

**4-5 minutes presentations in class**

Possible topics for the P442

1. Seesaw mechanism and the origin of neutrino mass
2. Limits on violation of Lorentz and CPT invariance in elementary interactions
3. A perfect liquid: the “quark-gluon plasma” observed in heavy ion collisions
4. Is the “Higgs” boson an elementary (point-like) object?
5. Utility of an inferred imbalance in transverse momentum in particle collisions.
6. Use of “ring-imaging” Cherenkov counters
7. Any other subject you wish to study (related to the topics at hand)

To get information on these subjects, start off with the web and Wikipedia (but be careful and check the facts). Don't cite Wiki, but always get the source. There are some good articles in Scientific American on many of these subjects.

**Final at the end: 25%**

**Date TBA**