I. The Standard Model

A. Quarks and leptons

1. Familiar particles from everyday life
2. Three families of quarks and leptons (similarities)
3. Notable differences between families

B. Bosons and forces

1. Electromagnetism and the photon
2. Weak force and vector bosons
3. Quantum Chromodynamics and gluons
4. Electroweak unification
5. Toward a GUT or TOE?

II. Electroweak Symmetry Breaking and the Higgs Mechanism

A. Standard model Lagrangian and massless vector bosons

1. Griffiths equations 10.129 and 10.136, with interpretation as new particle

B. Higgs mechanism breaks symmetry and provides mass to particles

1. W, Z bosons massive now
2. Yukawa couplings to other particles
3. Qualitative interpretation as particles being "slowed down" as they travel through field

III. Supersymmetry

A. Problems with the SM as currently formulated

1. Hierarchy problem: mass imbalances between particles, runaway Higgs mass from self-coupling
2. Matter-antimatter asymmetry
3. Does not explain dark matter
4. No unification of couplings at high energy

B. Basic structure of SUSY

1. Superpartners of particles
2. Boson-fermion symmetry

C. SUSY as a solution to problems mentioned above

1. Natural dark matter candidate
2. Can tune couplings to converge at high energy scale
3. Cancellation of terms solves Higgs self-coupling problem

4. Unitarity problem (look into this more)
5. Postpones hierarchy and CP violation problems

D. Simplified SUSY scenarios

1. Many parameters allowed
2. Constrain certain relationships to make problem more tractable
3. Free parameters left: tanβ, m_0, etc.

IV. Higgs Physics in Supersymmetry

A. 5 Higgs bosons in SUSY

1. 2 Higgs doublets with 8 DOF
2. 3 DOF already taken by massive vector bosons–5 left
3. 2 charged scalar, CP-odd pseudoscalar A, CP-even scalars h and H

B. Higgs couplings, SUSY as a broken symmetry

1. Mass as Higgs coupling $\times$ VEV
2. No SUSY particles seen, so they must be heavy

V. Higgs Phenomenology in Supersymmetry

A. Production cross sections

1. Plots of cross section as a function of mass and tanβ
2. Degeneracy of h and H/A at high tanβ
3. Feynman diagrams and interpretation for bH production

B. Branching fractions and widths

1. Plots of branching fractions in SUSY
2. Widths as calculated in FeyHiggs (or similar)
3. Lifetime

C. Limits from other experiments/measurements