Objectives for Material to be Learned from Unit 4

By the end of this unit, students should be able to do the following:

4.1 (Continuing objective) Describe quantum and elementary particle theories in your own words, and discuss applications of the material.

4.2 List the types of particles (bosons, fermions, hadrons, leptons, baryons, mesons, messengers) and their properties. Using data tables, classify and identify the properties of various fundamental particles.

4.3 Describe what happens if a particle combines with its anti-particle.

4.4 Name the six main conservation laws of particle physics and give the conditions under which they apply. Analyze given particle reactions or decays to test the main conservation laws, or to discover properties of a new unknown particle.

4.5 Build various hadrons with given properties from combinations of quarks, given a quark data table for up, down, and strange quarks.

4.6 State the four "fundamental" interactions and describe their properties; in particular, what kinds of particles they act on, their range, and their role in atomic and subatomic (as well as macroscopic) processes.

4.7 State and use the colorless rule for physically observable particles. Explain in words and sketches how gluons can change quark color.

4.8 Describe the role of virtual particles in Quantum Field Theory's description of particle interactions. Use the Energy-Time uncertainty principle to relate the mass of a virtual messenger particle to the range of the corresponding force.

4.9 Distinguish between quarks and leptons, describe which interactions they feel, and list which properties (color, flavor, family membership) are affected by which interactions.

4.10 Draw and use Feynman diagrams that include quark-gluon vertices, quark W-boson vertices, lepton-W boson vertices, or electron-photon vertices.

4.11 Construct correct interaction diagrams for given strong and weak interactions among particles, showing the underlying quark structure.

4.12 Given a particle's mass and quark constituents, list possible decay schemes and estimate decay times, using particle tables and the conservation laws.

4.13 Describe in words and diagrams a possible proton decay and explain why such an occurrence must be very rare.

4.14 Describe qualitatively the epochs of the Big Bang standard model of cosmology.

4.15 Calculate the energy, temperature, and time of critical events in the early universe (symmetry breaking, particle decoupling, etc.), given particle data tables. Relate the times/energies/temperatures to the types of particles that abundant during the different epochs.

4.16 Describe three observational evidences that serve as tests of the Big Bang model and modern particle physics.