Objectives for Material to be Learned from Unit 2

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

2.1 (Continuing objective) Relate the concepts of momentum, relativity, and rotations to "everyday" situations and discuss various applications of the concepts to practical problems in various fields of science, medicine and engineering.

2.2 Calculate the vector momentum of various objects.

2.3 State and recognize the conditions under which conservation of linear momentum applies.

2.4 Apply conservation of linear momentum to various isolated systems, including explosions and collisions in one or two dimensions. For elastic collisions, be able to use both conservation of momentum and conservation of energy (or alternately the equivalence between speed of approach and speed of recession) to solve for unknowns.

2.5 State the fundamental principles of relativity, and be able to explain how the various aspects of relativity all follow logically from these basic principles.

2.6 Relate measurements of a time interval in two different reference frames using the proper time relation, if one of the observers is at both events.

2.7 Relate length and distance measurements in two different reference frames using length contraction.

2.8 Calculate a spacetime interval between two events, and classify the interval as space-like, time-like, or light-like. Use these classifications to determine whether or not the two events can or cannot be causally linked.

2.9 Use the invariance of the interval to relate distance and time intervals in one reference frame to those in a different frame.

2.10 Draw and/or interpret a spacetime diagram, and use this diagram to determine time-ordering and spatial-ordering of events in various frames, including whether or not events are simultaneous or at the same location.

2.11 Use the velocity transformations to relate velocities as measured in different references frames.

2.12 Describe the modifications in the definitions of momentum and energy needed to maintain invariance of the conservation laws.

2.13 Given any two of p, E, u, K, and m for a particle, determine any of the others.

2.14 Use the invariance of a particle's mass to relate the particle's energy and momentum in one reference frame to those measured from a different frame.

2.15 Specialize any of the equations relating p, E, u, K, and m to zero-mass particles.

2.16 Apply the relativistic conservation laws to "explosions," in which one particle decays into two particles, including cases in which one or both outgoing particles have zero mass.

2.17 Apply the conservation laws to collisions with all particles traveling along a line.

2.18 Describe the processes of nuclear fusion and fission, and explain how these processes result in energy production.

2.19 Given information about nuclear masses, calculate the amount of energy released (that is, kinetic energy gained) in a fusion or fission process.

2.20 Given a graph of average mass per nucleon vs. nucleon number, explain how fusion reactions release energy for small nuclei, while fission reactions release energy for large nuclei.

2.21 Relate angular position θ, angular velocity ω, angular acceleration α, and time t. Relate linear speed to angular speed and distance. Use the no-slip condition to relate linear motion and rotational motion.

2.22 Relate rotational kinetic energy to rotational inertia and angular velocity. Solve conservation of mechanical energy problems involving rotational kinetic energy.

2.23 Calculate torque from the force and the position that the force is applied. Calculate angular momentum for particles from linear momentum and position, and angular momentum for extended objects from moment of inertia and angular velocity.

2.24 Use Newton's 2nd Law for rotational motion to relate net torque to the product of the moment of inertia and angular acceleration or to the rate of change of angular momentum. Also, combine this with $\vec{F}_{net} = m\vec{a}$ for systems with both angular and linear motion.

2.25 Correctly use the right hand rules: R H R #1 for vector cross products, and R H R #2 for determining directions of angular quantities.

2.26 Apply the conservation of angular momentum to situations where the net external torque equals zero or has a component equal to zero.