7.12: Symmetries and Invariance

This chapter has shown that the *symmetries* of a system lead to *invariance* of physical quantities as was proposed by Noether. The symmetry properties of the Lagrangian can lead to the conservation laws summarized in Table 7.12.1.

Table 7.12.1: Symmetries and conservation laws in classical mechanics

Symmetry	Lagrange property	Conserved quantity
Spatial invariance	Translational invariance	Linear momentum
Spatial homogeneous	Rotational invariance	Angular momentum
Time invariance	Time independence	Total energy

The importance of the relations between invariance and symmetry cannot be overemphasized. It extends beyond classical mechanics to quantum physics and field theory. For a three-dimensional closed system, there are three possible constants for linear momentum, three for angular momentum, and one for energy. It is especially interesting in that these, and only these, seven integrals have the property that they are *additive* for the particles comprising a system, and this occurs independent of whether there is an interaction among the particles. That is, this behavior is obeyed by the whole assemble of particles for finite systems. Because of its profound importance to physics, these relations between symmetry and invariance are used extensively.