10.8: Momentum Changes and Non-isolated Systems

Suppose the external force acting on the system is not zero,

$$\overrightarrow{\mathbf{F}}^{\text{ext}} \neq \overrightarrow{\mathbf{0}}$$

and hence the system is not isolated. By Newton's Third Law, the sum of the force on the surroundings is equal in magnitude but opposite in direction to the external force acting on the system,

$$\overrightarrow{\mathbf{F}}^{\text{sur}} = -\overrightarrow{\mathbf{F}}^{\text{ext}}$$

It's important to note that in Equation (10.8.2), all internal forces in the surroundings sum to zero. Thus the sum of the external force acting on the system and the force acting on the surroundings is zero,

$$\overrightarrow{\mathbf{F}}^{\text{sur}} + \overrightarrow{\mathbf{F}}^{\text{ext}} = \overrightarrow{\mathbf{0}}$$

We have already found (Equation (10.4.9)) that the external force $\overrightarrow{\mathbf{F}}^{ext}$ acting on a system is equal to the rate of change of the momentum of the system. Similarly, the force on the surrounding is equal to the rate of change of the momentum of the surroundings. Therefore the momentum of both the system and surroundings is always conserved.

For a system and all of the surroundings that undergo any change of state, the change in the momentum of the system and its surroundings is zero,

$$\Delta \overrightarrow{\mathbf{p}}_{\text{sys}} + \Delta \overrightarrow{\mathbf{p}}_{\text{sur}} = \overrightarrow{\mathbf{0}}$$

Equation (10.8.4) is referred to as the **Principle of Conservation of Momentum.**