8.7: Kinetic and Total Momentum

If you have previously taken a physics course then you have probably noticed that a rather odd symbol is used for momentum, namely $\mathbf{\Pi}$, rather than the more commonly employed $\mathbf{p}$. The reason for this peculiar usage is that there are actually two kinds of momentum, **kinetic momentum** and **total momentum** (or canonical momentum), just as there are two kinds of energy, kinetic and total. The symbol $\mathbf{\Pi}$ represents total momentum while $\mathbf{p}$ represents kinetic momentum. Normally we don't need to distinguish between the two quantities, as they are generally equal to each other. However, we will find later in the course that it is crucial to make this distinction in the case of charged particles in a magnetic field. As a general rule, the total momentum is related to a particle's wave vector via the de Broglie relation,

$$\mathbf{\Pi} = \hbar \mathbf{k} \tag{8.7.1}$$

while the kinetic momentum is related to a particle's velocity,

$$\mathbf{p} = \frac{\mathrm{mu}}{\sqrt{1 - \dfrac{\mathrm{u}^2}{\mathrm{c}^2}}}. \tag{8.7.2}$$