7-23 $H = \sum_j p_j \dot{q}_j - L$

in rectangular coordinates

$L = \frac{1}{2}m(\dot{x}^2 + \dot{y}^2 + \dot{z}^2) - U$

Linear momentum components, i.e canonical momenta

$p_x = \frac{\partial L}{\partial \dot{x}} = m\dot{x}$; $p_y = \frac{\partial L}{\partial \dot{y}} = m\dot{y}$; $p_z = \frac{\partial L}{\partial \dot{z}} = m\dot{z}$

Then

$H = m\dot{x}\cdot\dot{x} + m\dot{y}\cdot\dot{y} + m\dot{z}\cdot\dot{z} - \left[\frac{1}{2}m(\dot{x}^2 + \dot{y}^2 + \dot{z}^2) - U\right]$

$= \frac{1}{2}\left[\frac{(m\dot{x})^2}{m} + \frac{(m\dot{y})^2}{m} + \frac{(m\dot{z})^2}{m}\right] - U$

$= \frac{1}{2m}\left(p_x^2 + p_y^2 + p_z^2\right] - U$

$\dot{q}_k = \frac{\partial H}{\partial p_k}$; $-\dot{p}_k = \frac{\partial H}{\partial q_k}$

so (using the second of these)

$$\left.\begin{aligned} \dot{p}_x &= -\frac{\partial U}{\partial x} = F_x \\ \dot{p}_y &= -\frac{\partial U}{\partial y} = F_y \\ \dot{p}_z &= -\frac{\partial U}{\partial z} = F_z \end{aligned}\right\} \text{Newton's } 2^{nd} \text{ Law}$$