(5.4) The Lagrangian for a free particle is $L = -mc^2/\gamma$. Find an expression for L, p and H when $v \ll c$.

We have

$$p = \gamma m v \tag{5.23}$$
$$H = \gamma m c^2 \tag{5.24}$$

For $v \ll c$, γ is near unity.

$$\gamma = \frac{1}{\sqrt{1 - v^2/c^2}} \approx 1$$

Then for $\gamma = 1$ we have

$$L = -mc^2$$
$$p = mv$$
$$H = mc^2$$