1. Verify that
\[
\left(1 + \frac{\vec{\eta} \cdot \vec{\sigma}}{2}\right) (E - \vec{\sigma} \cdot \vec{p}) \left(1 + \frac{\vec{\eta} \cdot \vec{\sigma}}{2}\right) = (E - \vec{\eta} \cdot \vec{p}) - \vec{\sigma} \cdot (\vec{p} - E \vec{\eta})
\]
where \(\vec{\eta} = (\eta_1, \eta_2, \eta_3)\) is an infinitesimal velocity vector, \(\vec{\sigma} = (\sigma_1, \sigma_2, \sigma_3)\) are Pauli matrices.

2. Show that \(\psi \dagger \sigma^\mu \psi\) and \(\chi \dagger \sigma^\mu \chi\) transform separately as a 4-vector. Here \(\sigma^\mu \equiv (1, \vec{\sigma})\), \(\vec{\sigma}^\mu \equiv (1, -\vec{\sigma})\).

3. Consider two-component spinors with undotted indices, \(\zeta\) and \(\chi\).
(a) What is \(\zeta \cdot \chi\) in terms of \(\chi \cdot \zeta\)?
(b) What is \(\chi^a \zeta^a\) in terms of \(\chi^a \zeta^a\)?

4. If \(\chi\) is a two-component spinor with undotted indices,
(a) Show that \(i \sigma_2 \chi\) transform as \(V^*\).
(b) Use (a) to show that \((i \sigma_2 \chi)^T \zeta\) is Lorentz invariant.