Problem VI.1.

Show that the Mandelstam variable \( t \equiv (p_1 - p_3)^2 \), for the case that \( m_1 = m_3 \) and \( m_2 = m_4 \), can be written in the CM system exactly as \(-2p_1^*(1 - \cos(\theta^*))\), where \(|p_1^*|\) stands for the length of the three-momentum vector of \( p_1 \) in the CMS, and \( \theta^* \) is the angle between three-vectors \( p_1 \) and \( p_3 \) in the CMS.

Problem VI.2.

Show that the phase-space element \( dp/E \) is a Lorentz invariant quantity.

Problem VI.3

a) Calculate \( \frac{d\sigma}{d\Omega^*} \) and the total cross section \( \sigma_{tot} \) for electromagnetic lowest-order electromagnetic scattering of spin-0 bosons A and B (you may consider "spinless" \( e\mu \) scattering), both with charge \(+e\).

b) How does the result change for bosons that have opposite charges?

Hints: no hints
Solution: no solution yet

Problem VI.4

a) Calculate the decay width \( \frac{d\Gamma}{d\Omega^*} \) and the mean lifetime \( \tau \) for the weak decay of a spinless "muon" into spinless "electron" and two more spinless "neutrinos": \( \mu \rightarrow \nu_\mu + e^+ + \nu_e \). Assume all final state particle masses can be ignored compared to the muon mass. Assume the weak coupling constant is \( e \) as for electromagnetism, and that the weak boson propagator is \(-ig^\mu\nu/(q^2 + M_W^2) \approx -ig^\mu\nu/M_W^2\).

b) Compare to the experimental value of the muon lifetime and discuss.

Hints: no hints
Solution: no solution yet