

Reading: Chapters 1 and 2.1-2

Problems:

1. Williams, Problem 1.1
2. Williams, Problem 1.3
3. Williams, Problem 1.5. Skip the derivation, but illustrate your discussion with a sketch of the cross section, marking deviations.
4. (a) Prove that the energy  $E$  and momentum  $\vec{p}$  of a particle with rest mass  $m$  are related by

$$E = \sqrt{(m c^2)^2 + (p c)^2} .$$

Start with the equations for  $E$  and  $\vec{p}$  in terms of the particle's velocity  $\vec{v}$ .

(b) The Lorentz 4-momentum  $p^\mu$  for a particle is the 4-component vector  $(p^0, p^1, p^2, p^3) = (E/c, p^1, p^2, p^3)$ . The Lorentz product of the 4-momenta  $p_1^\mu$  and  $p_2^\mu$  for two particles is defined by

$$p_1 \cdot p_2 = \frac{E_1 E_2}{c^2} - \vec{p}_1 \cdot \vec{p}_2 .$$

Use the Lorentz transformation equations for  $E$  and  $\vec{p}$  to prove that  $p_1 \cdot p_2$  is invariant under Lorentz transformations.

(c) Determine  $p \cdot p$  for a particle of mass  $m$ .

5. Williams, Problem 2.1