

Homework Assignment #5

PS303 Modern Physics

Due Date: February 27, 2018 (Tuesday)

Mass $\rightarrow MeV/c^2$ not kilograms !!

Momentum $\rightarrow MeV/c$ not kilograms·meters/sec !!

Energy $\rightarrow MeV$ not joules !!

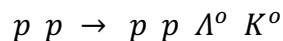
unless otherwise specified.

When you are asked for velocities, always quote your answers in units of “c,” the speed of light.

$$\text{velocity} = \beta c$$

Problems:

1. A proton is moving towards a fixed target (containing protons at rest) producing the following reaction:



Calculate the minimum kinetic energy required to make this reaction occur.

Hint: this problem is easier if you use the relativistic invariant: $P^\mu \cdot P_\mu$ in the appropriate inertial frames.

2. Calculate the mean-free-path between collisions of air molecules at 20°C.

Hint: use the equation $\ell = \frac{1}{n\sigma}$ where ℓ is the mean-free-path, n is the number density of air molecules (N/V) which can be found from the Ideal Gas Law, and σ is the cross-sectional area of an N_2 molecule. Assume the *diameter* of an N_2 molecule is ~ 0.300 nm, and that its cross-sectional area is *circular*.

3. The International Space Station (ISS) is 72.8 meters wide as it travels around the earth at 4.76 miles/sec. **Note:** It's actually traveling in the direction of its width.

By how much does the width of the ISS shrink when measured by someone in the earth's inertial frame?