

Caltech – Ph106a – Fall 2001

Problem Set 5

due 11-21-2001

- (a) M&T 9-23 (Slowing neutrons). Fission of $^{236}\text{U}^*$ produces a fast neutron, but slow neutrons have a much larger absorption rate in ^{235}U . So part of the design of a nuclear reactor involves “moderators,” designed to slow down neutrons through elastic collisions with some non-fissile nucleus. What elements are best to be used as moderators? Explain.

(b) M&T 9-26 (Maximum energy loss). A particle of mass m_1 elastically collides with a particle of mass m_2 at rest. What is the maximum fraction of kinetic energy loss for m_1 ? Describe the collision.
- H&F 3-4 (gas oscillator).
- M&T 7-36 (focusing a beam). Discuss the implications of Liouville’s Theorem on the focusing of beams of charged particles by considering the following simple case. An electron beam of circular cross section (radius R_0) is directed along the z -axis. The density of electrons across the beam is constant, but the momentum components transverse to the beam (p_x and p_y) are distributed uniformly over a circle of radius p_0 in momentum space. If some focusing system reduces the beam radius from R_0 to R_1 , find the resulting distribution of the transverse momentum components. What is the physical meaning of this result? (Consider the angular divergence of the beam). Can you guess, based on this, why the tendency of electrons to radiate when accelerating can actually be an *advantage* in getting a highly focused beam? *You may ignore interactions among the electrons.*
- H&F 5-3 (Routhian).
- H&F 5-11 (relativistic particle in E-M field).
- Optional challenge problem:** H&F 5-2 (Lenz vector).