

## Physics 247: Relativistic Dynamics 1

(Note, for many of these questions they are most easily answered if you use units where energy is in MeV, GeV and  $c=1$ )

1) An electron of rest mass energy  $mc^2 = 0.511$  MeV moves with respect to the laboratory at speed  $u = 0.6c$ . Find (a)  $\gamma$ , (b)  $p$  in units of MeV/c, (c)  $E$  in units of MeV, and (d)  $E_k$  in units of MeV.

2) You are designing the new galactic Republic space Force defense battleship for protecting against the Sith empire attacks. It launches, using a magnetic rail gun, one kg iron slugs at  $0.9c$ ,  $0.99c$  and  $0.999c$ . The battleship weighs 45 million kg.

a) How much relativistic energy and relativistic kinetic energy does the iron slug have at each of its launch energies. Give your answer in both GeV and Joules.

b) Using the concept of conservation of relativistic momentum what velocity is the battleship moving with after it fires each velocity of slug if the ship is initially stationary in each case.

c) Would it be a good idea for Sith warrior to use her command of the Force to slow the slugs to a stop before they hit her ship? Assume with dark side Force powers cannot violate special relativistic and conservation of momentum principles.

3)

How much energy would be required to accelerate a particle of mass  $m$  from rest to a speed of (a)  $0.5c$ , (b)  $0.9c$ , (c)  $0.99c$ . Express your answer in multiples of the rest energy.

4) The orbital speed of the Sun relative to the center of the Milky Way is about  $250\text{km/s}$ . By what fraction do the relativistic and Newtonian values differ for (a) the Sun's momentum and (b) the Sun's kinetic energy?

5) An electron has kinetic energy of  $5 m_e c^2$  in the lab frame. A muon has the same kinetic energy but is moving in the opposite direction. What is the 4-momentum of the electron in the muon frame?