

# Physics 370 Homework #3

6 problems

Due by Monday, September 12th

▷ 1.

Prove that Let  $u$  be the velocity of a particle in the  $x$  direction in frame  $S$ ; let  $u'$  be the velocity of the particle in frame  $S'$  which is moving in the  $x$  direction with speed  $v$  in  $S$ 's frame. When  $c = 1$ , prove that

$$\gamma_{u'} = (1 - uv)\gamma_v\gamma_u$$

▷ 2.

What are the momentum, energy, and kinetic energy of a proton moving at  $0.8c$ ?

▷ 3.

A spring has a force constant of  $18\text{ N/m}$ . If it is compressed  $50\text{ cm}$  from its equilibrium length, how much mass (in  $\text{kg}$ ) will it have gained?

▷ 4.

Two objects collide with one another. Before the collision, object A has mass 16 (in arbitrary units) and velocity  $0.6c$  to the right, and object B has mass 9 and velocity  $0.8c$  to the left. After the collision, both objects have the same speed as before, but in the opposite directions.

(a) Prove that the momentum is conserved before and after the collision.

(b) Calculate the change in kinetic energy of the system before and after the collision.

(c) Use the relativistic velocity transformation to find the four velocities in a frame moving to the right at  $0.6c$ .

(d) Show that the momentum is conserved before and after the collision.

(e) Calculate the change in kinetic energy of the system before and after the collision.

▷ 5.

Consider a set of  $N$  particles with mass  $m_i$  and velocity  $u_i$  in frame  $S$ . The total momentum of the set is

$$p = \sum_{i=1}^N \gamma_{u_i} m_i u_i$$

Find the total momentum  $p'$  in frame  $S'$  which is moving at velocity  $v$  with respect to  $S$ . Show that  $p'$  is equal to  $p$  plus another term: what is the other term?

▷ 6.

The light from galaxy NGC 221 consists of a recognizable spectrum of wavelengths. However, all are shifted toward the shorter-wavelength end of the spectrum. In particular, the calcium “line” ordinarily observed at  $396.85\text{ nm}$  is observed at  $396.58\text{ nm}$ . Is this galaxy moving toward or away from Earth? At what speed?