

# NYU Physics I—Problem Set 13

Due Thursday 2017 December 7 at the beginning of lecture.

**Problem 1:** Get a sense of the speed of light by computing two things:

- (a) How many times could light go around the equator of the Earth in a time interval of 1 s?
- (b) How long (in ns) does it take light to go 1 ft?

**Problem 2:** From the notes at <http://cosmo.nyu.edu/hogg/sr/>, Problem 3–4.

**Problem 3:** From the notes at <http://cosmo.nyu.edu/hogg/sr/>, Problem 2–14.

**Problem 4:** (a) What is  $\gamma$  to first order in  $\beta^2$  for  $\beta \ll 1$ ? That is, construct a Taylor Series for  $\gamma$  in terms of  $\beta^2$  and give the zeroth-order term (1) and then the first-order term.

(b) What are  $\beta$  and  $\gamma$  for a person walking (relative to the sidewalk), a driver on the freeway (relative to the road), a commercial jet (relative to the air), and an astronaut in the ISS (relative to the center of mass of the Earth)? Use the first-order expression from part (a) to compute the  $\gamma$  values.

(c) Computing the full time dilation effect in gravity is complicated! However, the pure kinematic part of the time dilation only depends on  $\gamma$ . Two twins part. One gets on the ISS for a year, and one stays on Earth. When they are reunited in a year, how much younger is the astronaut than the homebody?

**Extra Problem (will not be graded for credit):** If the total energy (rest mass plus kinetic) of a point particle is  $\gamma m c^2$ , use the result from Problem 3 above to get an approximate expression for the kinetic energy at low speeds.