Assignment X, HONS 158 (Honors Physics II)
Spring 2016
Due 4/20/16 at start of class

As always, please put your answers on separate paper. Note! Some of the problems on this homework assignment involve speeds very close to the speed of light. Assume throughout the homework that $c \equiv 3 \times 10^8$ m/s exactly (even though that's not exactly right). Whenever possible, leave answers as decimal or fractional multiples of c (unless specifically asked not to). Finally, since we are often talking about relatively minor effects, make sure to keep many digits in your computation until the end of the problem! Don't round off halfway through the problem; keep all your digits until the end and then, as appropriate, round to the appropriate number of significant figures.

1. You are on a meteor with a clock on it that is screaming past Earth with speed v. You are wearing a wrist-watch and it appears (to you) that 1 second elapses on your watch in the same time that 1 minute elapses on Earth. Assuming your watch is running correctly, how fast does the meteor move with respect to Earth? (Write your answer as a decimal multiple of c). Keep at least 5 digits of decimal precision.

2. A strobe light in a club flashes on and off once every 0.2 s as measured by the DJ in the club. How much time elapses between the strobe light as measured by an astronaut in a spaceship moving towards earth with a speed of $0.65c$?

3. You and a friend travel through space on *identical* spaceships. Your friend informs you that he has made some length measurements and that his ship is 150 m long but that your's appears to him to only be 120 meters long.

   a) From your point of view, how long is your friend's ship?

   b) From your point of view, how long is your own ship?

   c) From your point of view, haw fast is your friend's ship moving with respect to your ship?

4. Two asteroids head straight for Earth coming from the same direction (with respect to Earth). Their speeds relative to earth are 0.85c for asteroid 1 and 0.70c for asteroid 2. Find the speed of asteroid 1 relative to asteroid 2. (Assume all motion is in 1 dimension).

5. An electron moves to the right in a particle accelerator with a speed of 0.82c (with respect to the lab). A different (positively) charged particle moves to the left in the same accelerator with a speed of 0.73c *with respect to the electron*. Find the speed of the second particle relative to the lab.

6. An object has a total energy that is 8.3 times its rest energy. What is its speed?

7. Two spaceships approach Earth with equal speeds, as measured by an observer on Earth, but from opposite directions. A meterstick on one spaceship is measured to be 60 cm long by an occupant of the other spaceship. What is the speed of each spaceship, as measured by the observer on Earth?

8. If the total energy of a particle of mass m is equal to three times its rest energy, then what is the magnitude of the particle's relativistic momentum?

9. Let $0 < v_1 < c$ and $0 < v_2 < c$ where v_1 and v_2 represent two velocities pointing in the same direction. Let v equal the relativistic sum of the velocities $v_1 + v_2$ so that $v = \frac{v_1+v_2}{1+\frac{v_1 v_2}{c^2}}$. Note! In all parts of the problem below, I'm trying to have you show the solution in general for any v_1 and v_2 that obey the properties outlined above. Don't plug in numbers! This is more of a mathematical proof.

   a) Using the relativistic velocity addition formula, show that v must be greater than v_1.

   b) Similar to the above, use the relativistic velocity addition formula to show that v must be greater than v_2

   c) Similar to the above, use the relativistic velocity addition formula to show that $v < c$ (even if v_1 and v_2 are both larger than $0.5c$!)

10. (Extra Credit). The proper length of one spaceship is three times that of another spaceship. The two spaceships are traveling in the same direction and, while both are passing overhead, an Earth observer measures the two spaceships to have the same length. If the slower spaceship is moving with a speed of 0.35c (with respect to Earth), determine the speed of the faster spaceship (with respect to Earth).