Physics 7312 — Professor Scalise
Homework Assignment #12 — Spring 2023

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1. A uranium nucleus splits into barium and krypton nuclei. Find the speed of each daughter nucleus in symbols and numerically.

2. Read:
http://math.ucr.edu/home/baez/physics/Relativity/SR/acceleration.html
http://math.ucr.edu/home/baez/physics/Relativity/SR/rocket.html
http://www.astrophysicsspectator.com/topics/specialrelativity/Accelerated.html

   Remember that the relativistic analog of the Newtonian force (the force that you would actually feel and measure, the force that does work and changes the kinetic energy) is

$$\mathcal{F} = \frac{dP}{dt} = \frac{d}{dt}(\gamma m v)$$

   (a) Suppose that a new fuelless engine subjects a rocket of rest mass $m$ to a constant force $\mathcal{F}_o$. The people inside the rocket will be thrown to the back of the rocket and they will feel an acceleration $\mathcal{F}_o/m$. If the rocket starts near Earth from rest, find the speed of the rocket (as measured by an observer on Earth) after the engine acts for a time $t$ (as measured by an observer on Earth).

   (b) Find the distance (as measured by an observer on Earth) that the rocket travels in time $t$ (as measured by an observer on Earth).

   (c) If the felt acceleration is set to one Earth gravity (one "g") 9.8 m/s$^2$ for the comfort of the people inside the rocket, how long (as measured by an observer on Earth) will the rocket take to reach the nearest star Proxima Centauri, 4.22 lightyears from Earth? (Alpha Centauri A and B form a double star system and lie 4.35 ly from Earth).

   (d) How long (as measured by an observer on the rocket) will the rocket take to reach Proxima Centauri?

   (e) How fast will the rocket be going (as measured by an observer on Earth) as it flies by Proxima Centauri?

   (f) Show that the felt acceleration is related to the acceleration of the rocket (as measured by an observer on Earth) by

$$\mathcal{F}_o/m = \gamma^z \frac{d^2x}{dt^2}$$

   and find the exponent $z$.

   Notice that when you accelerate forward, you create an event horizon behind you. Anything further behind you than this horizon can never reach you, not even light. If a second ship further behind you than this horizon fired a laser beam at you, it would never reach you – you would outrun light!

   (g) How far behind you is the event horizon?

**BONUS** (due when the homework is due):

Three small spaceships A, B, and C drift freely in a region of space remote from other matter, without rotation and relative motion, with B and C equidistant from A (see figure). The spaceships are at rest relative to an inertial frame S. At one moment two identical signals from A are emitted towards B and C. On simultaneous (with respect to S) reception of these signals the motors of B and C are ignited and they accelerate gently along the straight line connecting them. Let ships B and C be identical, and have identical acceleration programmes. Then each point of B will have at every moment the same velocity as the corresponding point of C, and thus any two corresponding points of the ships will always be at the same distance from one another, all measured in S. Let us suppose that a fragile thread connects two identical projections placed exactly at the midpoints of B and C before the motors were started. If the thread with no stress is just long enough to span the initial distance in question, then as the ships accelerate the thread travels with them. Assume that the thread does not affect the motion of the ships. Will the thread break when B and C reach a sufficiently high speed? Explain.