General Relativity or “GR” (PHYS 325): PS 1 Spring 2026 v1.5

As he pondered the long futile fight
To make Galileo’s world right,
In a new variation
Of the old transformation,
It was Einstein who first saw the light.
- D. Morin.

This first material is on special relativity with an emphasis on the foundations of Lorentz transformations, spacetime coordinate notation, and the geometry of flat spacetime. New notation, diagrams, methods of calculating, and concepts abound!

All numbered problems are from Schutz. The chapter is given first, then the problem or ‘exercise’ in Schutz’s lingo, e.g. 1.13 is the 13th exercise of Chapter 1.

Reading:

Chapter 1 in Schutz.
Section 2.1 on vectors
Other useful resources include Einstein’s 1905 SR paper (there’s a link on the course page)

Problems: Due Thursday, Jan. 29 at 11 PM on Gradescope. The code to enroll and submit is 7KBNVJ.

(1) Work out the following in $c = 1$ units. (See 1.1 for a worked example.)
  (a) 1 J = 1 kg m^2/s^2 (You can see why we might not use this “c=1” set of units in intro lab!)
  (b) 1×10^{-34} J s (the reduced Planck’s constant)
  (c) The distance from the science center to KJ in seconds.

(2) 1.2 parts (a), (c), and (e)

(3) Draw the worldline, or t axis (with units of seconds), and x axes (with units of light seconds) for an observer $\mathcal{O}$ and add:
  (a) The worldline of an assistant at $x = 4$ ls (light seconds). Assume the assistant and the observer are in the same frame.
  (b) The worldline of light signal that the observer sends to the assistant at $t = -2$ s and that reflects off the assistant, returning to the observer.
  (c) At what time does the signal reflect off the assistant? At what time does the signal return to the observer?
  (d) Sketch the curve defined by $\Delta S^2 = -2$.

(4) As we did in class for an analogous expansion with δ_{ij} expand

$$\eta_{\mu\nu}\Delta x^\mu \Delta x^\nu$$

to show that

$$\Delta S^2 = \eta_{\mu\nu}\Delta x^\mu \Delta x^\nu$$

You don’t have to write out every term but do include at least a representative sample of terms.

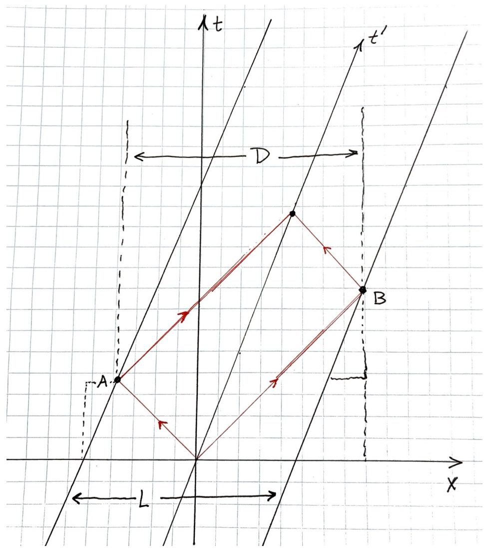
(5) 1.7 Finding $M_{\alpha\beta}$

(6) 1.10 ‘ID’ing intervals

(7) 1.14 Using the Maclaurin (or ‘Taylor’) series for the key results of SR.

(8) (2 pts.) 1.17 A version of the classic ‘pole in barn’ paradox

(9) (2 pts.) Using this diagram



show that the ‘slip in simultaneity’ is

$$\Delta t = t_B - t_A = \frac{vD}{c^2}.$$