Group Problems #1
Solutions

Tuesday, August 23

Problem 1 *Galilean Transformation*

You are driving at a steady 100 km/h. At noon you pass a parked police car. At twenty minutes past noon, the police car passes you, traveling at 120 km/h.

(a) How fast is the police car moving relative to you? $v_d = 100$ km/h and $v_p = 120$ km/h $\Longrightarrow \Delta v = 20$ km/h.

(b) When did the police car start driving, assuming that it accelerated from rest to 120 km/h instantaneously? In 20 minutes (1/3 hour), the driver goes $100 \cdot 1/3$ km. Traveling at 120 km/h, it takes the police car $\Delta t_p = (100/3\,\text{km})/(120\,\text{km/h}) = 5/18$ hour. So the police car starts 1/3 - 5/18 = 1/18 hour after the car passes.

(c) How far away from you was the police car when it started? After 1/18 h, the car has traveled 1/18 h $\cdot$100 km/h = 50/9 km.

(d) Plot the trajectories of the driver and police car on a graph (x vs. t). Now plot the trajectories as t vs. x.

(e) Plot the trajectories (t vs. x) from the driver's perspective: the rest frame of the driver.

(f) Plot the trajectories (t vs. x) in the police car's rest frame.

(g) Label the event coordinates in all three reference frames: Earth, Driver, Police. Use convention (t, x) for coordinates:

In Earth frame: A(0, 0); B(1/18 hour, 0); C(1/3 hour, 100/3 km).

In Driver frame: A(0, 0); B(1/18 hour, -50/9 km); C(1/3 hour, 0).

In Police frame: A(0, 0); B(1/18 hour, 0); C(1/3 hour, 0).

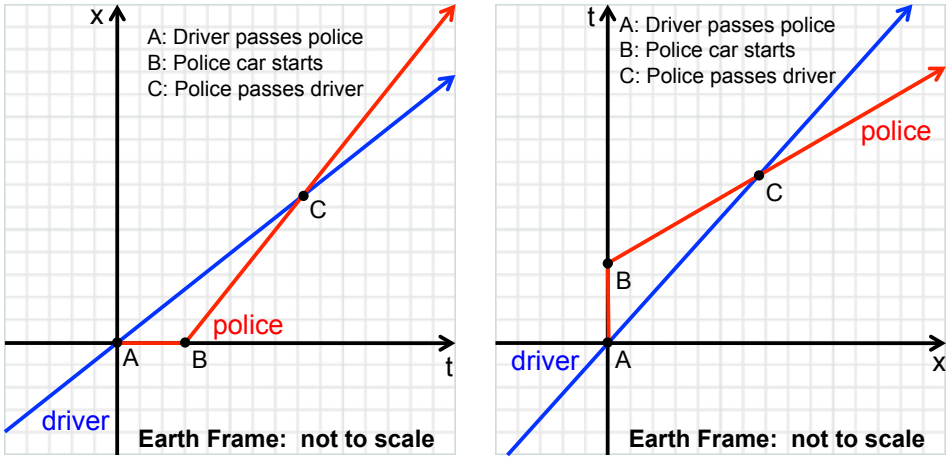

Figure 1: Space-time diagrams in the Earth frame. The left panel shows x vs. t, while the right panel shows t vs. x.

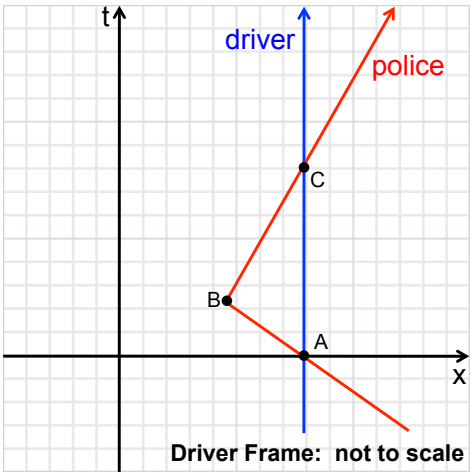

Figure 2: Space-time diagram in the driver frame.

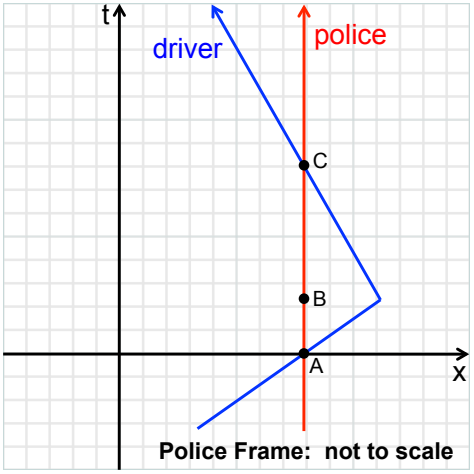

Figure 3: Space-time diagram in the police frame.