

LORENTZ TRANSFORMATIONS AND SIMULTANEITY

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References: Griffiths, David J. (2007), Introduction to Electrodynamics, 3rd Edition; Pearson Education - Chapter 12, Post 13.

Here's a simple example of using the Lorentz transformations. Suppose that two events occur simultaneously in the Earth frame, a distance 500 km apart. An observer in a (very fast) plane travelling at $\frac{12}{13}c$ along the line joining the events passes the first event A such that their respective coordinate origins coincide at that event. At what time does the plane observer think event B occurs?

The Lorentz transformations are

$$\bar{x} = \gamma(x - vt) \quad (1)$$

$$\bar{t} = \gamma\left(t - \frac{xv}{c^2}\right) \quad (2)$$

Event A occurs at the same time $t = \bar{t} = 0$ in both systems. For event B , $x = 500$ km and $t = 0$, so

$$\bar{t} = \gamma\left(-\frac{500v}{c^2}\right) \quad (3)$$

$$\gamma = \frac{13}{5} \quad (4)$$

$$\bar{t} = -\frac{13}{5}\left(\frac{12c \ 500}{13 \ c^2}\right) \quad (5)$$

$$= -\frac{1200}{c} \quad (6)$$

$$= -\frac{1200 \text{ km}}{3 \times 10^5 \text{ km s}^{-1}} \quad (7)$$

$$= -4 \times 10^{-3} \text{ s} \quad (8)$$

Thus the plane observer thinks that B occurs 4 milliseconds before A .