Theoretische Physik I: Klassische Mechanik - Präsenzübung

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Übungsblatt 12

Aufgabe 12.1: Synchronizing clocks.

Consider Bob, in his traincar of length L. There is a clock at the front of the car and another at the back of the car, and one at the middle of the car, where Bob stays. Bob wishes to synchronize the clocks, at least in his reference frame.

In the first approach, Bob sends a flash of light to each clock, which travels at the speed c. The clocks are set to $t = 0$ at the moment when the flashes arrive. At the same instant $t = 0$, the clocks send flashes back to Bob. Bob times the total elapsed time between when he sends a flash and when it returns: Δt. At the instant that the two flashes return, he sets his clock to time $t = \Delta t/2$.

12.1a)

Show that, from Bob's perspective, all the clocks read $t = \Delta t/2$ at the instant that the light returns to Bob's clock. What is the value of Δt?

12.1b)

Alice is moving with velocity $-v$ with respect to Bob (or Bob is moving with velocity $+v$ with respect to Alice). In Alice's reference frame, how different are the two times, namely, when the clock at the back of Bob's traincar is set to $t = 0$ and when the clock at the front of the traincar is set to $t = 0$?

Bob worries about relying on light. So he decides to rely on graduate students instead. Bob has two graduate students with skateboards who can move at the exact same speed v', which is different from (slower than) the speed of light. Bob sends the two graduate students out toward the two clocks. Each sets the clock to $t = 0$ at the moment when he/she reaches it, and then reverses direction and goes back to Bob, still at velocity v'. At the instant when the students reach Bob, he notes the total time they took, Δt, and sets his clock to $\Delta t/2$.

12.1c)

Show that, from Bob's perspective, all three clocks read $t = \Delta t/2$ at this moment, so this is also a good way to synchronize clocks. What is the value of Δt?

Consider this operation from Alice's perspective.

12.1d)

What are the speeds of the two graduate students as they head out to reach the clocks, in Alice's frame of reference? Remember to use the addition of velocities formula.

12.1e)

What is the time difference between when the graduate student at the back of the train sets a clock to $t = 0$, and when the graduate student at the front of the train does so? Is this the same or different than you found using light? Remember that both the students and the train are moving, and that the train is length contracted.

12.1f)

Show that the time difference between the three clocks, in Alice's perspective, is exactly the same as if Bob had used light – regardless of what value v' should take.

12.1g)

What can we conclude about the relativity of simultaneity? Does it depend on using light for coordinating clocks, or is it more general?