PH2102 Problem Set

2

Q 1) Alice is standing beside a straight high-speed train track. Bob is riding in an ultra-fast train traveling along the track at a speed v with respect to Alice. Bob is standing at the rear end of a compartment, whose length he measures to be L_0 (since the compartment is at rest with respect to Bob, this is its proper length - thus justifying the suffix "0"). At the instant at which Bob crosses Alice he fires a bullet towards the front of the compartment. The bullet travels with a speed u with respect to Bob and when it strikes the metallic front wall of the compartment a flash of light is emitted.

Consider the three events

- A : Bob fires the bullet
- B : The bullet hits the front wall of the compartment
- C : The light from the flash reaches Bob

Assume that both Bob and Alice sets their clocks to 0 when event A occurs.

a) Determine the time at which for events B and C occur according to Bob.

Let the speed of the bullet as measured by Alice be w (do not use the velocity addition formula - relativistic or otherwise, at this stage).

b) Determine the times at which events B and C occur according to Alice (do not forget to take into account that Alice observes the train compartment to be contracted).

c) Use the time dilation formula to relate the appropriate time intervals and use it to derive the expression $w = \frac{u+v}{1+uv/c^2}$.

Q 2) We derived the length contraction formula in the class by using the K-calculus approach. There we used light flashes sent out by Alice to locate

the left and right ends of a rod carried by Bob. To determine the length of the rod, Alice had to ensure that the two ends were being measured simultaneously. However, measuring the two ends simultaneously is not essential - you can correct for the distance the rod moves in the time interval between the two measurements. Show that this leads to the correct formula for length contraction (In the notation used in class, you can use arbitrary τ_1 and τ_2 - there is no need to insist on $t_L = t_R$).