AS.171.201/207 Homework 2 – Zakamska – Fall 2017

Problem 1 (3 points). Consider the Minkowski space-time diagram in Figure 1. Can the blue world line belong to Mary traveling on a rocket? Can the red world line belong to her? Why? Calculate the interval Δs^2 between events M and N. Now suppose a ladybug is flying in the negative x direction with velocity $0.9c$. What interval would she measure between events M and N?

Problem 2 (5 points). In class we discussed the following problem: a truck with proper length L crosses over a weigh station at speed $v = 0.8c$. The proper length of the weigh station platform is also L.

(a – 1 point). Replicate the solution we had in class: For how long (as measured in the platform frame) is the entire truck on the platform? Express the answer using L and c. Remember that proper length is the length of the object as measured in the object's own frame.

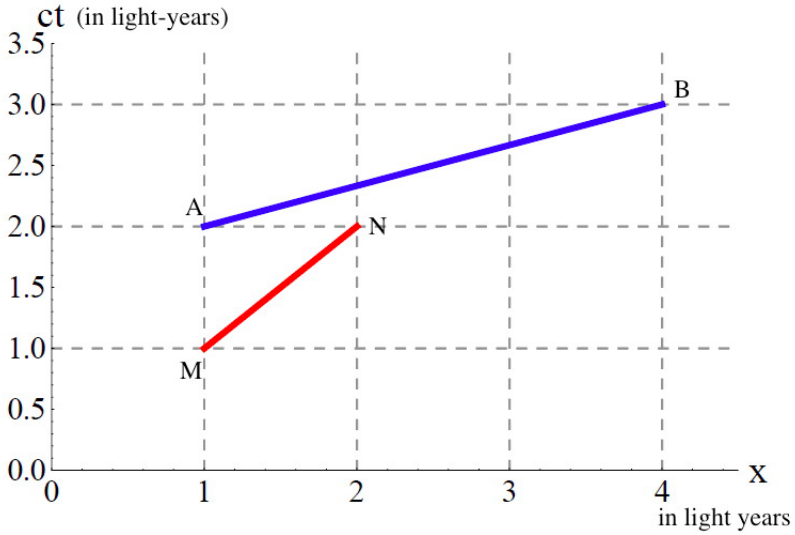
(b – 2 points). Let event number 1 be the back of truck getting onto the platform and event number 2 be the front of the truck getting off the platform. Draw two Minkowski diagrams for these events: one diagram in the frame of the platform, one diagram in the frame of the truck. Comment on the order of events in both frames. Can the two events be causally connected? Why? Use L as the unit for both axes of the Minkowski diagram.

(c – 2 points). Calculate the interval between the two events in the frame of the platform and in the frame of the truck. Is this interval time-like, space-like or light-like? Using the value of the interval, determine whether the two events can be causally connected and compare to your answer in b.

Problem 3 (3 points). Problem 6.3 from lecture notes (arXiv:1511.02121) on the equivalence between velocity addition equations and the Lorentz transform of the velocity 4-vector.

Problem 4 (4 points). Problem 6.7 from lecture notes on the 4-vector of charge density and current density.

Problem 5 (3 points). A radioactive nucleus is moving with uniform velocity $0.05c$ relative to the laboratory. (a) As seen in the frame of the nucleus S', the nucleus decays by emitting an electron with a speed $0.8c$ along the direction of motion (the common $x - x'$ axis). Find the velocity (magnitude and direction) of the electron in the lab frame. (b) The nucleus decays by emitting an electron with speed $0.8c$ along the positive y' axis. Find the velocity (magnitude and direction) of the electron in the lab frame. (c) The nucleus decays by emitting an electron with a speed $0.8c$ along the positive y-axis (i.e., perpendicular to the original motion o the nucleus in the lab frame). Find the speed of the electron and the direction of emission in the original rest frame of the nucleus S'.


ct (in light-years)
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0
1
2
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4
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in light years
A
B
M
N