Review Questions
(week of 11 May 2020)

1. How do we define an inertial frame of reference?
2. The 2nd law of Newton's dynamics says $\mathbf{F} = m\mathbf{a}$. From here follows that if $\mathbf{F} = 0$, then $\mathbf{v} = \text{const}$, which is what the first law says. Does it mean that we do not need the first law?
3. What is a non-inertial frame of reference? Give an example.
4. Write down the Galilean transformation (in the standard configuration[1] of two FoRs). Is there any implicit assumption here?
5. How does the non-relativistic velocity addition rule follow from the Galilean transformation?
6. State the postulates of the Special Theory of Relativity.
7. How do we synchronize clocks in the STR?
8. Write down the Lorentz transformation. How can we quickly get the inverse transformation?
9. Is the the Galilean transformation a special case of the Lorentz transformation? If so, when?
10. Is time an absolute quantity?
11. What is length contraction? Time dilation? Relativity of simultaneity?
12. Is it possible that two events are simultaneous in all inertial FoRs? Explain your answer.
13. Two events are temporally–separated in one FoR. Are they temporally–separated in all other FoRs?
14. A rod rests on the x axis of frame of reference S. When measured in S its length is 1 m. What is the length of the rod as measured in frame of reference S' moving at $v = c/\sqrt{2}$ with respect to S along the x–axis?
15. Explain how muons, created at the altitude of 9 km above the sea level and living 2 μs, can make it to the Earth's surface.
16. (exercise, not a quiz question) Starting from the Lorentz transformation (in the standard configuration of two FoRs) derive the relativistic velocity addition rule.
17. The relativistic velocity addition rule (in the standard configuration of two FoRs) has the form

$$u'_x = \frac{u_x - v}{1 - \frac{vu_x}{c^2}}, \qquad u'_y = \frac{u_y}{1 - \frac{vu_x}{c^2}}\sqrt{1 - \frac{v^2}{c^2}}, \qquad u'_z = \frac{u_z}{1 - \frac{vu_x}{c^2}}\sqrt{1 - \frac{v^2}{c^2}}.$$

Two particles travel along a straight line in the positive x axis direction: particle 1 with speed $c/2$, particle 2 with $2c/3$. What is the relative speed of particle 1 with respect to particle 2?

[1] Whenever we refer to "the standard configuration", we mean that the FoR S' moves with constant speed v along the x axis of the FoR S, and the corresponding axes S and S' coincide with each other at the initial instant.