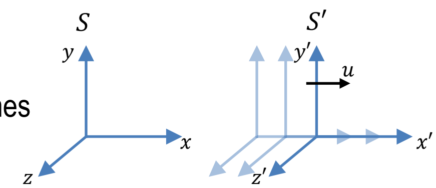
CONCEPT: LORENTZ TRANSFORMATIONS OF POSITION

● In Galilean relativity, relating the position of an event in two frames is quite simple
- In Special Relativity, it turns out this is not that simple, for two reasons:
1) You cannot simply add velocities as you could in Galilean Relativity
2) The time duration in one frame is NOT the same as in the other frame

● LORENTZ TRANSFORMATIONS are general relationships between quantities in two separate inertial reference frames
- These are general because they work at any speed, whereas the Galilean transformations only work at low speed
- Note that these transformations only work between two INERTIAL frames

● To use Lorentz transformations, you need two things:
- First, the two frames you choose have to have their axes and origins aligned
- Second, you have to choose the axis of the relative velocity between the frames
- A relative velocity is known as a BOOST, and it is typically in the x-direction



● For a frame S' with a boost of u along the x-axis, the LORENTZ TRANSFORMATIONS FOR POSITION are given by

$t' =$ ________________ $x' =$ ________________

$y' =$ ________________ $z' =$ ________________

EXAMPLE: Consider two frames, S and S', which have their origins aligned at $t = t' = 0$. If an event occurs in S at $x = 10\ cm$ and $t = 5s$, at what position and time does the event occur in S' if S' moves at 580 km/s in the x-direction?

PRACTICE: DISTANCE AND TIME TO TRAVEL IN A LAB FRAME

In a lab frame, S, an object crosses a distance of 15 m in 10 s. In an initially aligned frame S', moving at 1000 km/s in the x-direction relative to S, how far a distance does the object have to travel, and in what time does it travel the distance?

CONCEPT: LORENTZ TRANSFORMATIONS OF VELOCITY

● If we know the velocity in one frame, and we want to find the velocity in another, we need Lorentz Transformations
- It's not good enough to simply add the velocities, like in Galilean Relativity

● To use Lorentz transformations for velocities, we need to apply the same conditions on the frames as for position:
- The two frames need to have their axes and origins aligned
- You need to choose a boost direction for S', typically in the x-direction

● For a frame S' with a boost of u along the x-axis, the LORENTZ TRANSFORMATIONS FOR VELOCITY are given by

$v_x{}' =$ ____________________

$v_y{}' =$ ____________________

$v_z{}' =$ ____________________

EXAMPLE 1: A spaceship passes the Earth at 0.5 c. From an observer on the ship, a missile is fired forward at 0.1 c. According to an observer on Earth, how fast is the missile moving?

EXAMPLE 2: A spaceship passes the Earth at 0.7 c. From an observer on the ship, a missile is fired laterally (from the side of the ship, perpendicular to its direction of motion) at 0.2 c. According to an observer on Earth, how fast is the missile?

PRACTICE: NUCLEAR DECAY IN A PARTICLE ACCELERATOR

In a particle accelerator, a neutron is traveling at a speed of 0.7 c, as measured by you in a laboratory. This neutron decays (becoming a proton), ejecting an electron. If you measure the electron's speed to be 0.5 c, traveling in the same direction as the neutron, what was the relative speed between the electron and neutron when the neutron decayed? Was the electron ejected forward or backwards relative to the neutron's motion, as "seen" by the neutron?