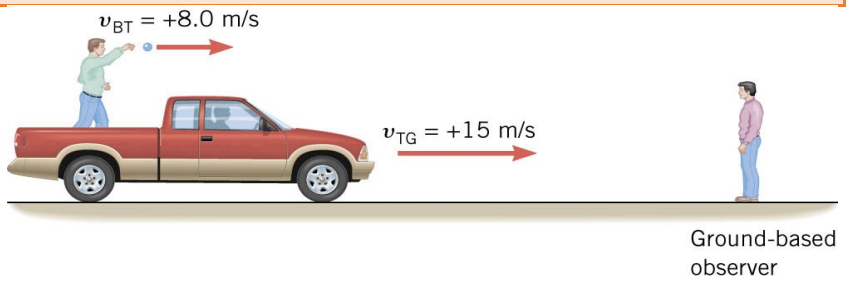
Relativistic Addition of Velocities

Classical physics

$$v_{BT} + v_{TG} = v_{BG}$$

$$v_{BT} = -v_{TB}$$

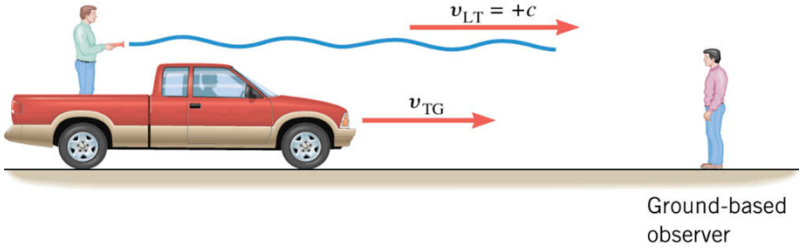


What if the combination of the _____ and the _____ added to be more than the speed of _____?

- The _____-based observer would observe the ball to travel _____ than light.
- This _____ happen.

Relativistic Addition of Velocity

$$v_{LG} = \frac{v_{LT} + v_{TG}}{1 + \frac{v_{LT} v_{TG}}{c^2}}$$



At what speed does the ground-based observer see the light travel?

Doppler shift for relative velocity

$$\lambda_{obs} = \lambda_s \sqrt{\frac{1 + \frac{u}{c}}{1 - \frac{u}{c}}}$$

- u is relative _____ of _____ to _____
  - Positive if moving _____

$$f_{obs} = f_s \sqrt{\frac{1 - \frac{u}{c}}{1 + \frac{u}{c}}}$$

The starship Enterprise moves at 0.9c relative to the earth and a Klingon Bird-of-Prey moves the same direction at 0.7c relative to the earth. What does the navigator of the Bird-of-Prey report for the speed of the Enterprise?

If the Enterprise has blue (λ = 475 nm) lights, what wavelength does the Klingon ship see as it leaves?

Physics 14-03 Relativistic Addition of Velocities ***Name: _____***

Practice Work

1. Explain the meaning of the terms "red shift" and "blue shift" as they relate to the relativistic Doppler effect.
2. What happens to the relativistic Doppler effect when relative velocity is zero? Is this the expected result?
3. Is the relativistic Doppler effect consistent with the classical Doppler effect in the respect that λ_{obs} is larger for motion away?
4. Suppose a spaceship heading straight towards the Earth at 0.750c can shoot a canister at 0.500c relative to the ship. (a) What is the velocity of the canister relative to the Earth, if it is shot directly at the Earth? (b) If it is shot directly away from the Earth? (OpenStax 28.20) **0.909c, 0.400c**
5. Repeat the previous problem with the ship heading directly away from the Earth. (OpenStax 28.21) **-0.400c, -0.909c**
6. If a spaceship is approaching the Earth at 0.100c and a message capsule is sent toward it at 0.100c relative to the Earth, what is the speed of the capsule relative to the ship? (OpenStax 28.22) **0.198c**
7. If a galaxy moving away from the Earth has a speed of 1000 km/s and emits 656 nm light characteristic of hydrogen (the most common element in the universe). (a) What wavelength would we observe on the Earth? (b) What type of electromagnetic radiation is this? (c) Why is the speed of the Earth in its orbit negligible here? (OpenStax 28.24) **658 nm, red, it's v << c**
8. A space probe speeding towards the nearest star moves at 0.250c and sends radio information at a broadcast frequency of 1.00 GHz. What frequency is received on the Earth? (OpenStax 28.25) **775 MHz**
9. If two spaceships are heading directly towards each other at 0.800c, at what speed must a canister be shot from the first ship to approach the other at 0.999c as seen by the second ship? (OpenStax 28.26) **0.991c**
10. When a missile is shot from one spaceship towards another, it leaves the first at 0.950c and approaches the other at 0.750c . What is the relative velocity of the two ships? (OpenStax 28.28) **-0.696c away**
11. Near the center of our galaxy, hydrogen gas is moving directly away from us in its orbit about a black hole. We receive 1900 nm electromagnetic radiation and know that it was 1875 nm when emitted by the hydrogen gas. What is the speed of the gas? (OpenStax 28.30) **0.01324c**