Special Relativity Exercises 3:

SIMULTANEITY, VELOCITY ADDITION & DOPPLER SHIFT

[easy] 1. How fast do you need to drive for a red light traffic light to look green?

[medium] 2. The [OII] emission line with rest-frame wavelength λ_o=372.7 nm is observed in a distant galaxy to be at λ=950.0 nm. What is the redshift and recession speed of the galaxy?

[medium] 3. Alice and Bob are on a space station that is exactly half way between two planets Alpha and Beta. Alice and Bob hop into their rocket ships and try to race each other to the planets. Alice heads off toward planet Alpha at speed v and Bob heads off toward planet Beta at speed v.

a) According to a stationary observer on the space station who wins the race?
b) According to Alice who wins the race?
c) According to Bob who wins the race?

[hard] 4a. We have previously developed Einstein's formula for the addition of velocities:

$$v_{CA} = \frac{v_{BA} + v_{CB}}{1 + \frac{v_{CB} v_{BA}}{c^2}}$$

a) Alice is in a rest frame and she observes a spaceship moving at 1/2c. Inside this spaceship Bob measures himself running forward at 1/2c .

Draw a spacetime diagram that represents:

a) The worldline of a ray of light emanating from the origin
b) Alice's worldline
c) The spaceship's worldline
d) Bob's worldline (think about time and distance in the appropriate axes).

4b. Determine the speed that Alice measures Bob moving at

d) Using the Einstein velocity addition formula

e) Reading it off your spacetime diagram