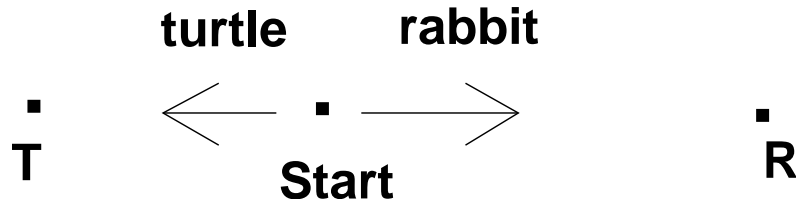
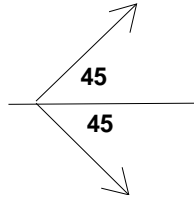


The rabbit and the turtle decide to have a race. They start at the same point and run in opposite directions with the same speed $0.8c$ and $0.6c$ respectively (the rabbit is faster of course). The rabbit is supposed to run to point R separated from the starting point by a distance of 6×10^8 m, and the turtle is supposed to run to point T, separated from the starting point by 4.5×10^8 m. A referee sitting on the ground watches the race and determines if the rabbit reaches point R before the turtle reaches point T.



- According to the referee who wins the race?
- According to the rabbit how long does it take for him to finish the race.
- According to the rabbit how fast is the turtle moving relative to him.
- According to the rabbit, how fast is point T moving and how fast is the turtle approaching point T?
- How long does the rabbit think it takes the turtle to finish the race?
- Who wins the race according to the rabbit? Does this contradict the findings of the referee?

A new particle moving in the positive x direction decays into two photons which make an angle of 45° relative to the x -axis. The photons are measured to have an energy of 99 MeV .



- Determine the velocity that the particle had in the x direction
- Determine the mass of this new particle.
- Determine what its energy and momentum were before it decayed.

You have an unknown light source, which emits light with a definite frequency f , and an unknown metal. You are given a known light source with wavelength $\lambda = 590 \text{ nm}$ and measure that when the metal is exposed to this known light source electrons emerge with velocity $v = 0.6 \times 10^6 \text{ m/s}$. When exposed to the unknown light the electrons emerge with velocity $v = 0.3 \times 10^6 \text{ m/s}$.

- Determine the frequency f .
- Estimate the size of relativistic effects.

You have an electron which moves around a nucleus with Z protons. In this problem start from the Bohr quantization condition $L = m_e v r = n\hbar$ and the coulomb law. If you are unable to do part one you can use formulas to do part 2 and 3.

- Determine the radius of the n -th orbital. Your answer should be a function of \hbar, m_e, c and α .
- Determine the radius numerically for the second orbital of the Li^{+3} nucleus, i.e. a nucleus with three protons.
- Again for Li^{+3} estimate the force in units of eV/nm on the electron in the second orbit. Compare this force to the force that an electron experiences in a strong Laboratory field electric field of 100 kV/cm .
- What is the wavelength of light emitted as the atom decays from the $n=2$ to the $n=1$ state.