

# PHYS UN1602 Recitation Week 11 Worksheet

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## Problem 1

The star Gliese 832 is located 16 lightyears away from the Earth. Suppose we send a spacecraft to investigate the recently discovered exoplanet in that star system with velocity  $v = \frac{4}{5}c$  and  $\gamma = \frac{5}{3}$ .

- a) According to the occupants of the spacecraft, how long does the trip take?
- b) According to the occupants of the spacecraft, how far did they travel?
- c) Once they arrive, they send a light-based signal back to Earth. According to the people on Earth, how much time passed between the spacecraft leaving and the signal being received?

## Problem 2

High-energy photons propagating through space can convert into electron-positron pairs by scattering with cosmic microwave background (CMB) photons. Taking the average CMB temperature of 2.8 K, a typical CMB photon will have an energy of roughly  $7 \times 10^{-4}$  eV. Calculate the minimum energy required for the high-energy photon to produce an electron-positron pair ( $m_e = 511$  keV) if:

- a) The CMB photon momentum is perpendicular to that of the high-energy photon.
- b) The CMB photon propagates in the direction opposite the high-energy photon.
- c) Suppose the CMB photon propagates in the same direction as the high-energy photon. Is it ever possible for the two photons to collide and produce an electron-positron pair?