Relativity-3: Practice Problems

1. Spacecraft Alpha has the speed v_α with respect to the Earth. If spacecraft Beta goes past Alpha at a relative speed of $0.5c$ in the same direction, what is the speed of Beta with respect to the Earth?
   $[c(c + 2v_\alpha)/(2c + v_\alpha)]$

2. A certain cosmic ray particle has a lifetime of $1.5 \times 10^{-6}\,\mathrm{s}$, when measured in its proper frame. How far can it travel if its speed is $0.99c$? $[3.2\,\mathrm{km}]$

3. Calculate the velocity of $1\,\mathrm{MeV}$ electrons. $[0.86c]$

4. An electron moves with speed $0.8c$. Calculate its mass, momentum, kinetic energy and total energy. $[15.18 \times 10^{-31}\,\mathrm{kg}, 0.68\,\mathrm{MeV}/c, 0.34\,\mathrm{MeV}, 0.85\,\mathrm{MeV}]$

5. Two subatomic particles travel in opposite directions, one (particle A) with a speed of $0.95c$ and the other (particle B) with a speed of $0.8c$. Both speeds have been measured with respect to a stationary observer. Calculate the velocity of particle A with respect to particle B. $[0.994c]$

6. The proper lifetime of a certain particle is $0.1 \times 10^{-6}\,\mathrm{s}$. How long is it seen to live, moving at a speed of $0.96c$? How far does it travel, as seen by a stationary observer? $[0.36\,\mu\mathrm{s}, 103\,\mathrm{m}]$

7. Two spaceships approach the Earth from opposite directions. According to an observer on the Earth, ship A is moving at a speed of $0.753c$ and ship B at a speed of $0.851c$. What is the speed of ship A, as observed from ship B? $[0.98c]$

8. Rocket A travels with a speed of $0.8c$ in the postive y-direction relative to the Earth, and rocket B travels with a speed of $0.6c$ in the negative x-direction relative to the Earth. What is the magnitude and direction of the velocity of rocket A as seen from rocket B? $[0.88c, 46.85°]$

9. An air plane is moving with respect to the earth with a speed of $800\,\mathrm{ms}^{-1}$. As determined by an earth clock, how long will it take for the airplane's clock to fall behind by $2\,\mu\mathrm{s}$?
   $[5.63 \times 10^5\,\mathrm{s}$ or $6.51\,\mathrm{days}]$

10. What is the speed of a rocket so that its length is contracted to 99.99% of its rest length? $[0.014c]$

11. A sample of radioactive material, at rest in the laboratory, ejects two electrons in opposite directions. One of the electron has a speed of $0.6c$ and the other has a speed of $0.7c$ as measure by a laboratory observer. Find their relative velocity. $[0.92c]$

12. Joe leaves the earth in a spacecraft that makes a round trip to the nearest star $4\,\mathrm{lightyears}$ away, at a speed of $0.9c$. Upon his return, how much younger will he be than his twin sister who remained behind? $[5\,\mathrm{yrs}]$

13. A star is receding from the earth at a speed of $5 \times 10^{-3}c$. What is the wavelength shift for the sodium D_2 line (5890Å)? $[29$Å$]$

14. An electron is accelerated through a potential of $10^5\,\mathrm{V}$. Calculate the speed and the momentum of the electron. $[0.55c, 0.337\,\mathrm{MeV}/c]$

15. A rocket is chasing an enemy spaceship. An observer on the earth records the speed of the rocket to be $2.55 \times 10^8\,\mathrm{ms}^{-1}$, and that of the spaceship to be $2.25 \times 10^8\,\mathrm{ms}^{-1}$. Calculate the velocity of the enemy spaceship as seen by the rocket, and also the velocity of the rocket as seen by the enemy. $[-0.28c, 0.28c]$