

- 11 •• A friend of yours who is the same age as you travels to the star Alpha Centauri, which is 4 light-years away and returns immediately. He claims that the entire trip took just 6 y. How fast did he travel?
- 19 •• A beam of unstable particles emerges from the exit slit of an accelerator with a speed of  $0.89c$ . Particle detectors 3.0 and 6.0 m from the exit slit measure beam intensities of  $2 \times 10^8$  particles/cm<sup>2</sup>·s and  $5 \times 10^7$  particles/cm<sup>2</sup>·s, respectively. (a) Find the proper half-life of the particles. (b) Determine the beam intensity at the exit slit of the accelerator. (c) The accelerator is adjusted so that the particles emerge from the exit slit with a speed of  $0.96c$ . The beam intensity at the farther detector is again  $5 \times 10^7$  particles/cm<sup>2</sup>·s. Find the beam intensity at the exit slit of the accelerator.
- 32 • How fast must you be moving toward a red light ( $\lambda = 650$  nm) for it to appear green ( $\lambda = 525$  nm)?
- 43 •• A particle moves with speed  $0.8c$  along the  $x''$  axis of frame  $S''$ , which moves with speed  $0.8c$  along the  $x'$  axis relative to frame  $S'$ . Frame  $S'$  moves with speed  $0.8c$  along the  $x$  axis relative to frame  $S$ . (a) Find the speed of the particle relative to frame  $S'$ . (b) Find the speed of the particle relative to frame  $S$ .
- 79 •• A rocket with a proper length of 1000 m moves in the  $+x$  direction at  $0.6c$  with respect to an observer on the ground. An astronaut stands at the rear of the rocket and fires a bullet toward the front of the rocket at  $0.8c$  relative to the rocket. How long does it take the bullet to reach the front of the rocket (a) as measured in the frame of the rocket, (b) as measured in the frame of the ground, and (c) as measured in the frame of the bullet?