9. (a) The rest length L_0 = 130 m of the spaceship and its length L as measured by the timing station are related by Eq. 37-13. Therefore,

$$L = L_0\sqrt{1-(v/c)^2} = (130\,\mathrm{m})\sqrt{1-(0.740)^2} = 87.4\,\mathrm{m}.$$

(b) The time interval for the passage of the spaceship is

$$\Delta t = \frac{L}{v} = \frac{87.4\,\mathrm{m}}{(0.740)(3.00\times10^8\,\mathrm{m/s})} = 3.94\times10^{-7}\,\mathrm{s}.$$

13. (a) The speed of the traveler is v = 0.99c, which may be equivalently expressed as 0.99 ly/y. Let d be the distance traveled. Then, the time for the trip as measured in the frame of Earth is

$$\Delta t = d/v = (26\text{ ly})/(0.99\text{ ly/y}) = 26.26\text{ y}.$$

(b) The signal, presumed to be a radio wave, travels with speed c and so takes 26.0 y to reach Earth. The total time elapsed, in the frame of Earth, is

$$26.26\text{ y} + 26.0\text{ y} = 52.26\text{ y}.$$

(c) The proper time interval is measured by a clock in the spaceship, so $\Delta t_0 = \Delta t/\gamma$. Now

$$\gamma = \frac{1}{\sqrt{1-\beta^2}} = \frac{1}{\sqrt{1-(0.99)^2}} = 7.09.$$

Thus, Δt_0 = (26.26 y)/(7.09) = 3.705 y.

29. (a) One thing Einstein's relativity has in common with the more familiar (Galilean) relativity is the reciprocity of relative velocity. If Joe sees Fred moving at 20 m/s eastward away from him (Joe), then Fred should see Joe moving at 20 m/s westward away from him (Fred). Similarly, if we see Galaxy A moving away from us at 0.35c then an observer in Galaxy A should see our galaxy move away from him at 0.35c, or 0.35 in multiple of c.

(b) We take the positive axis to be in the direction of motion of Galaxy A, as seen by us. Using the notation of Eq. 37-29, the problem indicates v = +0.35c (velocity of Galaxy A relative to Earth) and u = –0.35c (velocity of Galaxy B relative to Earth). We solve for the velocity of B relative to A:

$$\frac{u'}{c} = \frac{u/c - v/c}{1-uv/c^2} = \frac{(-0.35)-0.35}{1-(-0.35)(0.35)} = -0.62\,,$$

or $|u'/c| = 0.62$.

33. (a) In the messenger's rest system (called S_m), the velocity of the armada is

$$v' = \frac{v - v_m}{1 - vv_m/c^2} = \frac{0.80c - 0.95c}{1 - (0.80c)(0.95c)/c^2} = -0.625c\ .$$

The length of the armada as measured in S_m is

$$L_1 = \frac{L_0}{\gamma_{v'}} = (1.0\,\text{ly})\sqrt{1 - (-0.625)^2} = 0.781\ \text{ly}\ .$$

Thus, the length of the trip is

$$t' = \frac{L'}{|v'|} = \frac{0.781\text{ly}}{0.625\text{c}} = 1.25\ \text{y}\ .$$

(b) In the armada's rest frame (called S_a), the velocity of the messenger is

$$v' = \frac{v - v_a}{1 - vv_a/c^2} = \frac{0.95c - 0.80c}{1 - (0.95c)(0.80c)/c^2} = 0.625c\ .$$

Now, the length of the trip is

$$t' = \frac{L_0}{v'} = \frac{1.0\,\text{ly}}{0.625c} = 1.60\ \text{y}\ .$$

(c) Measured in system S, the length of the armada is

$$L = \frac{L_0}{\gamma} = 1.0\,\text{ly}\sqrt{1 - (0.80)^2} = 0.60\ \text{ly}\ ,$$

so the length of the trip is

$$t = \frac{L}{v_m - v_a} = \frac{0.60\,\text{ly}}{0.95c - 0.80c} = 4.00\ \text{y}\ .$$