36.18. Solve: **(a)** The starting event is the astronaut leaving earth. The finishing event is the astronaut arriving at the star system. The time between these events as measured on earth is

$$\Delta t = \frac{4.5 \text{ ly}}{0.9c} = \frac{4.5 \text{ ly}}{0.9 \text{ ly / year}} = 5.0 \text{ years}$$

(b) For the astronaut, the two events occur at the same position and can be measured with just one clock. Thus, the time interval in the astronaut's frame is the proper time interval.

$$\Delta\tau = \sqrt{1 - \frac{v^2}{c^2}}\Delta t = \sqrt{1 - \left(\frac{0.9c}{c}\right)^2}\ 5.0 \text{ years} = \sqrt{0.19}\ 5.0 \text{ years} = 2.2 \text{ years}$$

(c) The total elapsed time is the time for the astronaut to reach the star system plus the time for light to travel from the star system to the earth. The time is

$$\Delta t + 4.5 \text{ years} = 5.0 \text{ years} + 4.5 \text{ years} = 9.5 \text{ years}$$