34.54. Model: Use the particle model for the astronaut.

Solve: According to Newton's third law, the force of the radiation on the astronaut is equal to the momentum delivered by the radiation. For this force we have

$$F = p_{\text{rad}}A = \frac{P}{c} = \frac{1000\ \text{W}}{3.0\times10^{8}\ \text{m/s}} = 3.333\times10^{-6}\ \text{N}$$

Using Newton's second law, the acceleration of the astronaut is

$$a = \frac{3.333\times10^{-6}\ \text{N}}{80\ \text{kg}} = 4.167\times10^{-8}\ \text{m/s}^2$$

Using $v_\text{f} = v_\text{i} + a(t_\text{f} - t_\text{i})$ and a time equal to the lifetime of the batteries,

$$v_\text{f} = 0\ \text{m/s} + (4.167\times10^{-8}\ \text{m/s}^2)(3600\ \text{s}) = 1.500\times10^{-4}\ \text{m/s}$$

The distance traveled in the first hour is calculated as follows:

$$v_\text{f}^2 - v_\text{i}^2 = 2a(\Delta s)_{\text{first hour}}$$

$$\Rightarrow (1.500\times10^{-4}\ \text{m/s})^2 - (0\ \text{m/s})^2 = 2(4.167\times10^{-8}\ \text{m/s}^2)(\Delta s)_{\text{first hour}} \Rightarrow (\Delta s)_{\text{first hour}} = 0.270\ \text{m}$$

This means the astronaut must cover a distance of 5.0 m – 0.27 m = 4.73 m in a time of 9 hours. The acceleration is zero during this time. The time it will take the astronaut to reach the space capsule is

$$\Delta t = \frac{4.73\ \text{m}}{1.500\times10^{-4}\ \text{m/s}} = 31{,}533\ \text{s} = 8.76\ \text{hours}$$

Because this time is less than 9 hours, the astronaut is able to make it safely to the space capsule.