Chapter 1 Problem 83 [†]

Given
$d = 42,188 \pm 25\ m$
$t = 2\ h\ 30\ min\ 12 \pm 1\ s$

Solution
a) Calculate the percent uncertainty in the distance.

Percent uncertainty is the fraction of error times 100 percent.

$$percent\ error = \frac{\Delta\ d}{d} \times 100\%$$

Percent uncertainty is the fraction of error times 100 percent.

$$percent\ error = \frac{25\ m}{42,188\ m} \times 100\% = 0.059\ \%$$

a) Calculate the percent uncertainty in the time.

Convert the time into seconds.

$$t = (2\ hr)\left(\frac{3600\ s}{1\ hr}\right) + (30\ min)\left(\frac{60\ s}{1\ min}\right) + 12\ s = 9012\ s$$

Percent uncertainty is the fraction of error times 100 percent.

$$percent\ error = \frac{\Delta\ t}{t} \times 100\%$$

$$percent\ error = \frac{1\ s}{9012\ s} \times 100\% = 0.01\ \%$$

c) Find the average speed of the runner.

Speed is given as distance divided by time.

$$v = \frac{d}{t} = \frac{42,188\ m}{9012\ s} = 4.6813\ m/s$$

Since time is only good to four significant digits, the speed is also good to four sig. figs. Theerefore,

$$v = 4.681\ m/s$$

d) What is the uncertainty in the average speed.

Since speed is calculated by dividing one value by another, the percentage of errors add. Therefore, the error in the average speed is

$$percentage\ error = 0.059\% + 0.01\% = 0.069\%$$

Applying this percentage of error to the average speed gives

$$\Delta\ v = v\ \left(\frac{percent\ error}{100\ \%}\right)$$

[†]Problem from University Physics by Ling, Sanny and Moebs (OpenStax)

$$\Delta\ v = (4.681\ m/s)\ \left(\frac{0.069\%}{100\ \%}\right) = 0.0032\ m/s$$

The average speed of the runner is

$$v = 4.681 \pm 0.003\ m/s$$