

Section 1.3/1.4 Standards and Units / Using and Converting Units

QUESTION [3] 1.3 How many **nanoseconds** does it take light to **travel 1.00 ft** in a vacuum? (This result is a useful quantity to remember.)

ANSWER 1.02 ns

• **Keywords & sig-figs**, then [nanoseconds=time] [travel=distance] [1.00 ft = 3 sig figs]

[1st – Extract Data] 50% of the credit on exams.

| Given (directly give) | Need (indirectly give) | Seeking |
|---|--|----------------|
| $\Delta x = 1.00 \text{ ft}$ $c = v_x = 299792458 \frac{\text{m}}{\text{s}}$ | (rate)(time) = (distance) $v_x \Delta t = \Delta x \Rightarrow \Delta t = \frac{\Delta x}{v_x}$ | $\Delta t = ?$ |

[2nd – Formulate Data] 50% of the credit on exams. Before doing any calculation, it is good to convert the units without approximating. If I just plug in what I have, the units do not match up. I will do this all-in-one shot. Without looking up the unit conversions, I am going to go off of what I remember—that is, 2.54 cm = 1 in, 100 cm = 1 m, and 12 in = 1 ft. (I had to look up in the book nanosecond conversion.)

$$\begin{aligned}
 \Delta t &= \frac{\Delta x}{v_x} = \frac{1.00 \text{ ft}}{299792458 \frac{\text{m}}{\text{s}}} = \frac{(1.00 \text{ ft}) \left(\frac{12 \text{ in}}{1 \text{ ft}}\right) \left(\frac{2.54 \text{ cm}}{1 \text{ in}}\right) \left(\frac{1 \text{ m}}{100 \text{ cm}}\right)}{299792458 \frac{\text{m}}{\text{s}}} \\
 &= \frac{(12)(2.54)}{100} \frac{\text{m}}{299792458 \frac{\text{m}}{\text{s}}} = \frac{(12)(2.54)}{[(100)(299792458)]} \text{ s}, \quad 1 \text{ ns} = 10^{-9} \text{ s} \Rightarrow 1 = \frac{1 \text{ ns}}{10^{-9} \text{ s}} \\
 &= \frac{(12)(2.54)}{[(100)(299792458)]} (1) \text{ s} = \frac{(12)(2.54)}{[(100)(299792458)]} \text{ s} \left(\frac{1 \text{ ns}}{10^{-9} \text{ s}}\right) \\
 &= \frac{(12)(2.54)}{[(100)(299792458)(10^{-9})]} \text{ ns} \approx 1.0167.
 \end{aligned}$$

[3rd – State the Answer] 0% of the credit on exams (but no credit without it).

$$\therefore \Delta t = 1.02 \text{ ns.}$$