Chapter 1 Problem 45 †

Given

10^9 electric components in an area of 4 mm by 4 mm

Solution

a) What is the length across each component?

Assume each component occupies the same area. Then the area per component is

$$\frac{Area}{component} = \frac{(4\ mm)(4\ mm)}{10^9} = 1.6 \times 10^{-8}\ mm^2$$

Assuming each component is a square, then the length on each side is the square root of the area.

$$l = \sqrt{A} = \sqrt{1.6 \times 10^{-8}\ mm^2} = 1.26 \times 10^{-4}\ mm$$

Converting this to meters gives

$$l = 1.26 \times 10^{-7}\ m$$

Since the original value was only good to one significant digit, then the answer is only good to one significant digit. The answer is then $1 \times 10^{-7}\ mm$.

b) Find the number of calculations that can be performed per second when 10^4 elements must be traversed a million times. (The electrical impulse travels at $3 \times 10^8\ m/s$.)

The distance traveled by the electrical impulse would have to equal the length of each component multipled by the number of components and the number of times each component must be traversed. Then the distance is

$$d = (1 \times 10^{-7}\ m/component)(10^4\ components)(1,000,000) = 1000\ m$$

In one second the electrical impulse travels $3 \times 10^8\ m$ so the number of calculations performed each second is

$$\frac{distance\ in\ one\ second}{distance\ for\ one\ calculation} = \frac{3 \times 10^8\ m}{1000\ m} = 3 \times 10^5\ calculations$$

†Problem from Essential University Physics, Wolfson