Name_____

Physics 110 Quiz #1, March 31, 2023

Please show all work, thoughts and/or reasoning to receive partial credit. The quiz is worth 10 points total.

I affirm that I have carried out my academic endeavors with full academic honesty.

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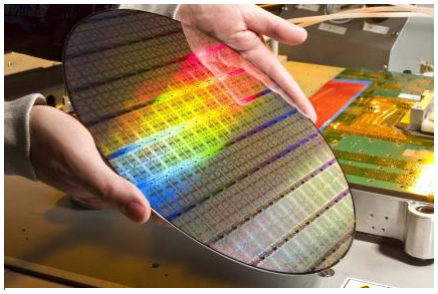
1. Computer chips like the one in your computer or phone are etched onto circular silicon wafers of thickness $0.30mm$. These circular wafers are sliced from a solid cylindrical silicon crystal of length $25cm$. If each wafer can hold 400 chips, what is the maximum number of computer chips that can be produced from the entire cylinder? A typical wafer is shown on the right, and each small square is a computer chip.



https://www.techspot.com/article/1840-how-cpus-are-designed-and-built-part-3/

The number of wafers n is given by the height h of the cylinder divided by the thickness s of a wafer. Thus, $h = n \cdot s \rightarrow n = \frac{h}{s} = \frac{25cm}{0.3mm \times \frac{1cm}{10mm}} = 833.3$, or 833 wafers. The total number of chips N is the number of wafers times the number of chips per wafer, or $N = 400n = 333{,}200$ chips.

2. From each chip above, many computers are made. Suppose that you are typing on your keyboard entering data onto your favorite computer. How many years would it take to fill up the hard drive in a computer that can store 256 gigabytes ($256 \times 10^9 bytes$) of data? Assume that you work $40hrs$ per week and that you can type 200 characters per minute and that one byte is one keyboard character.

$$t = 256 \times 10^9 bytes \times \frac{1char}{1byte} \times \frac{1min}{200char} \times \frac{1hr}{60min} \times \frac{1wk}{40hrs} \times \frac{1yr}{52wk} = 1.04 \times 10^4 yr$$

3. One use of your computer, of course, is in lab to collect and analyze data. Suppose you and your lab partner collect some data on the distance x (in meters) that an object travels in a time t (in seconds). You both try to determine the equation of motion of the object, or the equation that relates x to t. Both yours and your lab partner's equations of motion are below. If v (in meters per second) is the speed of the object and a (in meters per second squared) the acceleration, which of the following if any could be an equation of motion to describe the distance the object travels as a function of time? To earn full credit, show that yours or your partner's equation of motion can or cannot be correct and why.

   You: $x_{you} = (2v - 3a)t^2$

   The units of your equation of motion are: $\frac{m}{s} \times s^2 - \frac{m}{s^2} \times s^2 = ms - m \neq m.$ Your equation of motion cannot be correct.

   Your Lab Partner: $x_{partner} = 2vt - \frac{3a}{t^2}$

   The units of your partner's equation of motion are: $\frac{m}{s} \times s - \frac{m}{s^2} \times \frac{1}{s^2} = m - \frac{m}{s^4} \neq m.$ Your partner's equation of motion also cannot be correct.

4. Speaking of distances, the smallest meaningful measure of length is called the Planck length $l_p = \sqrt{\frac{Gh}{c^3}}$ and it is defined in terms of three fundamental constants of nature $c = 3 \times 10^8 \frac{m}{s}$, $G = 6.67 \times 10^{-11} \frac{m^3}{kg \cdot s^2}$, and $h = 6.63 \times 10^{-34} \frac{kg \cdot m^2}{s}$. Show that the Planck length does in fact have units of length (meters) and calculate the magnitude of l_p. The Planck length is used in the theory of elementary particles to set size scales of things like quarks (the constituent particles of protons and neutrons) and the electron.

   $l_p = \sqrt{\frac{Gh}{c^3}} = \sqrt{\frac{6.67 \times 10^{-11} \frac{m^3}{kg \cdot s^2} \times 6.63 \times 10^{-34} \frac{kg \cdot m^2}{s}}{\left(3 \times 10^8 \frac{m}{s}\right)^3}} = 4.1 \times 10^{-35} m$ where the units are given by $\sqrt{\frac{\frac{m^3}{kg \cdot s^2} \times \frac{kg \cdot m^2}{s}}{\frac{m^3}{s^3}}} = \sqrt{\frac{m^5 s^3}{s^3 m^3}} = \sqrt{m^2} = m.$