Physics 206a

Homework Assignment II
due January 19, 2007

First part: Units and Dimensions

Recall the distinction between units and dimensions: The dimension of a quantity tells us what variety of instrument would be used to measure it. E.g., a distance will always be measured by a ruler of some sort. One could not use a clock to measure a distance directly. One uses a clock to measure a time. On the other hand, the units of a quantity tell us specifics about the particular instrument that is being used. E.g., having decided that we will measure a distance with a ruler and not with a clock, we still have a choice of which ruler to use: We can use one calibrated in inches, cm, cubits, whatever happens to be convenient.

Also, units and dimensions combine via specific rules:

a) One cannot add or subtract quantities with unlike dimensions or units.

b) When multiplying or dividing (or raising to powers or taking roots), units or dimensions combine according to the rules of algebra along with the quantities with which they're associated.

c) When a quantity occurs as the argument of a non-algebraic function (such as a sine or exponential), it must be "dimensionless." What is a dimensionless quantity? Well, based on rule b), above, if two numbers are divided and they have the same dimensions, the quotient will have no dimension. Note that a quantity can have units but still be dimensionless! This occurs, for example, whenever a quantity is used to convert one unit to another. The conversion factor is dimensionless, but it has units, as you'll see in some of the examples below.

1. For each of the dimensions below, express at least three different units which might be used to measure them:
    a. Length
    b. Time
    c. Mass
2. The diameter of a human hair is approximately 50 μm. Calculate what this is in inches making sure to show how the units convert.
3. Consider the hair described above. What is the area of a cross-section of one shaft of such a hair? Express your answer in square meters (m^2), square centimeters (cm^2), and square inches (in^2).
4. "Speed" is the distance an object travels divided by the time it takes to travel that distance. What are the dimensions of speed? What is the unit for speed within the *SI* system?
5. A man is walking with a speed of $2\,\frac{\text{meters}}{\text{second}}$. Express this speed in miles per hour.
6. A very lazy snail is sliding along at a speed of $1\,\frac{\text{furlong}}{\text{fortnight}}$. Express this speed in meters per second.

Second part: Position and motion

7. A woman goes for a walk. She begins at the origin of a Cartesian coordinate system. After walking in a straight line for one kilometer, she turns right and walks perpendicular to her original path for ¾ of a kilometer.
    a. What are her coordinates at the end of this walk? Make whatever assumption you deem necessary to answer this. Explain your assumptions.
    b. What total distance did the woman walk?
    c. What is the woman's total displacement at the end of her trip (measured from her beginning point)?
8. Beginning in the sixteenth century (according to the best estimates), ships determined their speed, relative to the water, by throwing a "chip log" over the side. The log was attached to the ship by a rope into which knots were tied every 47.25 feet. The rope was allowed to unroll off a spool as the ship moved forward. The number of knots that came off the spool in a 30 second period was counted.
    a. If one "knot" came off the spool in 30 seconds, the ship was said to be traveling at a speed of 1 knot. How many "statute" (i.e., land-based) miles per hour is 1 knot? (1 statute mile = 5280 feet)
    b. One Nautical Mile is the distance a ship travels in one hour if it travels at a speed of one knot for one hour. It is *also* the length of one minute of arc along the Earth's equator. Using this, what is the circumference of the Earth in nautical miles?
    c. Using the result from (a) and (b), what is the circumference of the Earth in statute miles?

9. Consider a Cartesian coordinate system. A man goes for a walk beginning at a point which has coordinates $(-25.4\ \text{m}, 38.2\ \text{m})$—let's call the two directions x and y for the first and second number in the pair, respectively. He walks in the positive x direction for 22 meters and then walks in the positive y direction for 14 meters.
    a. What are his coordinates at the end of the walk?
    b. What total distance did he walk?
    c. What is his total distance from the origin of the coordinate system?
10. A vector oriented 45° relative to the x axis is added to a vector oriented parallel to the y axis. The first vector has a length of 3.2. The second vector has a length of –4 (i.e., it's pointed in the negative y direction). What is the length of the "resultant," i.e., the vector that results from the addition of the two?