

Homework #1

GRCC Physics 221

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1. Perform each of the following unit conversions and report your answer to the proper number of significant figures. You may use the following information:

$$0.225 \text{ pounds} = 1.00 \text{ newton}$$

$$1 \text{ mile} = \text{exactly } 5280 \text{ feet}$$

$$2.54 \text{ centimeters} = 1.00 \text{ inch}$$

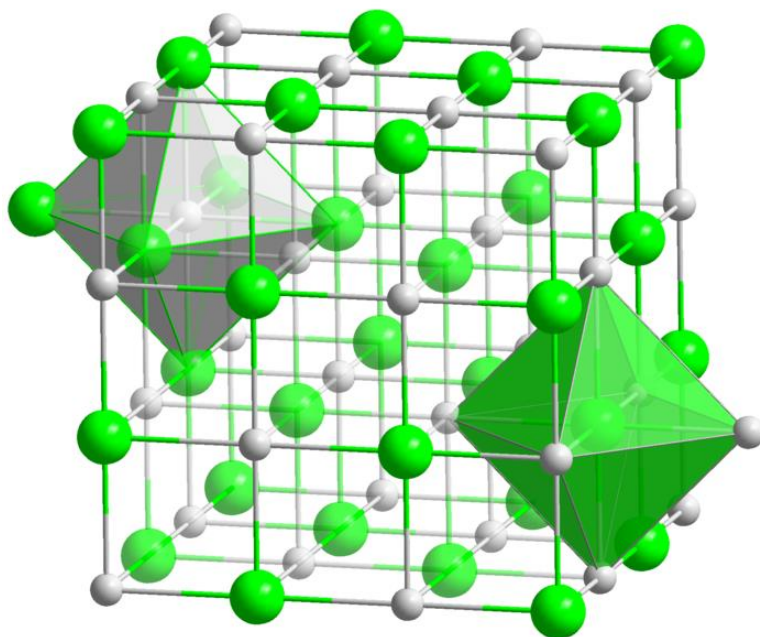
$$1 \text{ foot} = \text{exactly } 12 \text{ inches}$$

$$1 \text{ minute} = \text{exactly } 60 \text{ seconds}$$

$$1 \text{ hour} = \text{exactly } 60 \text{ minutes}$$

- a. In October of 2007, in Scotland's Inverness River, not far from the infamous Loch Ness, a 56 inch long salmon was caught. How long is that in centimeters?
 - b. In September of 2010, Cincinnati Reds pitcher Aroldis Chapman threw a baseball with a speed of 105.1 miles per hour. How fast is that in meters per second?
 - c. The SI unit of pressure is the pascal. One pascal is exactly one newton per square meter. The record for high atmospheric pressure in Seattle was set in 1921 when the barometer read 15.1 pounds per square inch. How much pressure is that in pascals?
2. As Hagrid explained to Harry, that there are 29 knuts in a sickle and 17 sickles in a galleon. J. K. Rowling has said that there are five British pounds to a galleon and at the time she said that there were 1.58 US dollars to a British pound. A boxed set of seven hardcover Harry Potter books retails for \$195.00. If Hagrid wants to buy the boxed set, what does he have to pay in galleons, sickles, and knuts? (Assume he pays with the maximum number of galleons and the minimum number of knuts.)
3. One fathom is 1.8 meters. One degree Celsius is 1.8 degrees Fahrenheit.
- a. A length of 7.0 fathoms is equal to how many meters?
 - b. A temperature of 7.0 degrees Celsius is equal to what temperature Fahrenheit?
 - c. Why are the previous two answers different?
4. The "cubit" is a unit of length that was common in biblical times. The Bible says that Solomon made a circular tank that was ten cubits across and thirty cubits around. This is often reported as an error in the Bible but think about it. Is it actually wrong? Explain your answer.

5. Rainfall is measured in “centimeters” or “inches.”
- In 1947 in the town of Holt, Missouri, it rained 12 inches in just 42 minutes. One acre is 43560 square feet. There are 7.48 gallons in a cubic foot. How many gallons of water fell on each acre of land in Holt, Missouri, in those 42 minutes?
 - In 1956 in the town of Unionville, Maryland, it rained 1.23 inches in just one minute. How many gallons of water fell on each acre of Unionville in that minute?
6. The density of sodium chloride is approximately 2.165 grams per cubic centimeter. The atomic mass of sodium is approximately 23.0. The atomic mass of chlorine is approximately 35.5. To this degree of accuracy, the atomic mass of an ion is the same as the atomic mass of an atom. Sodium chloride forms a “simple cubic” lattice which is to say that the atoms (or ions) lie on the corners of a cubic grid, like the integer-valued points on a Cartesian x-y-z coordinate system. Exactly half of the ions in sodium chloride are sodium ions and the other half are chlorine ions. The sodium ions take up the same amount of space as the chlorine ions. Since a cube has six square faces, each sodium ion has six chlorine ions for neighbors. Each chlorine ion has six sodium ions for neighbors.
- How many sodium ions are there in 1.00 cubic centimeter of sodium chloride?
 - What is the average distance between the center of one sodium ion and the center of a next-door neighbor chlorine ion?
 - What is the average distance between the center of one sodium ion and the center of the nearest sodium ion? It may help to draw a picture or look at a cube as a model. If one sodium atom is at one corner of the cube, the nearest sodium atom would be at the *opposite* corner of a face of the cube. See the picture below.



7. Great moments in television:

- The engineer reported to the captain that the shields were failing. The captain asked the science officer how long they would hold up. The science officer reported that they would last another 47.18 seconds. Without knowing much about shields and photon torpedoes, what do you think of the science officer's answer? Explain your reasoning.
- The "world's greatest forensic anthropologist" and the "king of the lab" were at a murder scene. The king of the lab found a worm near the corpse. He said these worms move one foot per day and the worm was 38.3 inches from the body. The world's greatest forensic anthropologist then calculated that this meant the time of death was three days, four hours, and thirty-six minutes ago. Without knowing much about worms and corpses, what do you think of her calculation?

8. The speed of sound can be calculated from atmospheric pressure and density. You could look up the formula but let's pretend you don't know how. Standard atmospheric pressure is (very nearly) 100,000 pascals. One pascal is one kilogram per "meter second squared" ($1 \text{ kg}/(\text{m s}^2)$). Notice that the seconds are squared but the meters are not. The density of air is about 1.2 grams per liter. One liter is 1000 cm^3 .

- Using *only the information above*, estimate the speed of sound in air.
- Now look up a measured value for the speed of sound in air. Calculate the relative error of your estimate. Express your result as a percentage.

9. While studying a problem in fluid dynamics, a student came up with some equations involving several variables that have the dimensions listed in the table below. Determine whether each equation (a through d) is dimensionally consistent or inconsistent.

[Note: the symbol r represents a radius and the symbol A represents an area.]

$[m] = M$	$[t] = T$	$[z] = L^2 T^{-1}$	$[P] = M L^{-1} T^{-2}$
$[v] = L T^{-1}$	$[x] = L$	$[f] = M L T^{-2}$	$[\eta] = M L^{-1} T^{-1}$

a) $z = \left(\frac{3}{5}\right) \frac{f}{\eta}$

b) $f = \sqrt{\pi r^2 (zP\eta)}$

c) $x = \frac{\eta Av}{f} - \frac{mz}{\eta}$

d) $\frac{f}{4\pi z} - P = Q$

e) Can a consistent equation be wrong?

f) Can an inconsistent equation be right?

10. The *Schwarzschild radius* of an object is the radius of a sphere of equivalent mass that would have such intense gravity that light could not escape (the object would be a black hole). The strength of gravity is given by $G = 6.7 \times 10^{-11} \text{ m}^3 \text{ kg}^{-1} \text{ s}^{-2}$. The speed of light is approximately $c = 3.0 \times 10^8 \text{ m/s}$. The mass of the Earth is $6.0 \times 10^{24} \text{ kg}$. Using only this information,

estimate the Schwarzschild radius of the Earth. You may compare your answer to the accepted value (which you could find on the Internet) if you wish.