## I. Objectives

1. Define the units commonly used in science.
2. Perform calculations using time, distance, mass, temperature and related units using the characteristics of various earth system objects and processes.

## II. Introduction

Read the entire lab and identify which conversion factors will be required **before** we begin the lab.

The ability to convert among time, distance, mass, and temperature units enables physical scientists to compare and contrast the characteristics of geography-related objects, as well as other objects throughout the universe. In this semester you will be required to make these kinds of conversions, so it is important that you understand how they are done and that you are able to do them yourself. None of the conversions require more than a working knowledge of arithmetic, scientific notation and a calculator. The process of converting one time, distance, or mass unit to another time, distance, or mass unit is the same no matter which units are required. Simply find a "chain" of conversion factors needed to change the existing units to the desired units and multiply the conversion factors together, "cancelling" units. This process is called dimensional analysis.

## III. Sample Calculations

1. Convert the velocity of light, $2.997925 \times 10^8$ *m/s* to *km/hr*.

$$\frac{2.997925 \times 10^8\ m}{1\ s} \times \frac{1\ km}{1{,}000\ m} \times \frac{60\ s}{1\ \text{min}} \times \frac{60\ \text{min}}{1\ hr}$$

$$= 1{,}079{,}253{,}000\ \text{km/hr} = 1.079253 \times 10^9\ \text{km/hr}$$

Answer: $2.997925 \times 10^8$ m/s $= 1.079253 \times 10^9$ km/hr

2. The average density of the Earth is 5,520 kg/m3. Convert it to g/cm$^3$.

$$\frac{5{,}520\ kg}{1\ m^3} \times \frac{1{,}000\ g}{1\ kg} \times \left(\frac{1\ m}{100\ cm}\right)^3 = 5.52\ \text{g/cm}^3$$

Answer: 5,520 kg/m$^3$ = 5.52 g/cm$^3$

3. Convert the Earth's sidereal period of rotation, 23*h* 56*m* 04.1*s*, to *s*.

$$\left(23\ hr\ x\ \frac{3{,}600\ s}{1\ hr}\right)+\left(56\ \text{min}\ x\ \frac{60\ s}{1\ \text{min}}\right)+4.1\text{s}$$

$$= 82{,}800\text{s} + 3{,}360\text{s} + 4.1\text{s} = 86{,}164\text{s} = 8.6164 \times 10^4\ \text{s}$$

Answer: 23h 56m 04.1s $= 8.61641 \times 10^4$s

Note: if a time is negative, remove the negative sign, perform the calculations and insert the negative sign in front of the result.

Note: h indicates hours, m indicates minutes, and s indicates seconds. Do not confuse m for meters and m for minutes. The context of the problem should make it clear which is being used.

4. Convert 80°F to °C and K.

$$°\text{C} = \frac{5}{9}(°\text{F} - 32°\text{F}) = \frac{5}{9}(80°\text{F} - 32°\text{F}) = 26.67°\text{C}$$

$$\text{K} = °\text{C} + 273°\text{C} = 26.67°\text{C} + 273°\text{C} = 299.67\text{K}$$

Answer: $80°\text{F} = 26.67°\text{C} = 299.67\text{K}$

5. Convert 45°C to °F and K.

$$°\text{F} = \frac{9}{5}(°\text{C}) + 32°\text{F} = \frac{9}{5}(45°\text{C}) + 32°\text{F} = 113°\text{F}$$

$$\text{K} = °\text{C} + 273°\text{C} = 45°\text{C} + 273°\text{C} = 318\text{K}$$

Answer: $45°\text{C} = 113°\text{F} = 318\text{K}$

Note: we will us the symbol ° for degrees interchangeably with d for degrees. Do not confuse ° used with temperatures and ° for angular measurements. The context of the problem should make it clear which is being used.

6. Convert the angle $32.23^{o}$ to degrees, arc minutes, and arc seconds.

$1^{o} = 60'$, so then:

$32.23^{o} = 32^{o} + 0.23*60' = 32^{o} + 13.8'.$

$1' = 60''$,

$32.23^{o} = 32^{o} + 13' + 0.8\ 60$

$32.23^{o} = 32^{o} + 13' + 48''$

$32.23^{o} = 32^{o}\ 13'\ 48''$

## IV. Prelab Definitions

1. conversion factor

2. meter

3. kilometer

4. angular degree

5. arcminute

6. arcsecond

7. mass

8. gram

9. kilogram

10. volume

11. density

12. weight

13. force

14. Newton

15. energy

16. joule

17. power

18. watt

19. speed

20. velocity

21. temperature

22. Fahrenheit

23. Celsius

## V. Lab Procedure

Perform each of the following calculations. Be sure that your answers include the correct units. **You must show your work to receive credit for the answers!** Be sure that your answers make sense.

1. Convert 1 day to seconds.

2. Another unit for expressing angles, besides degrees, arc minutes, and arc seconds is the *radian.* There are $2\pi$ radians in an entire circle. Therefore, how many degrees would there be in 1 radian? How many arc seconds in 1 radian?

3. How long does light from the Sun take to reach the Earth in minutes? Light travels at a speed equal to 300,000 km/sec. The distance from the Sun to the Earth is 150,000,000 km.

4. Convert the average density of Earth, 5.52 $g/cm^3$, to $kg/m^3$.

5. Atmospheric pressure on earth is equal to about 14.7 $lbs/in^2$. Convert that value to $g/cm^2$.

6. Two units of atmospheric pressure used frequently by earth scientists are the *atmosphere* [abbreviated atm] and *bar*. 1 atm = 1.0325 bar. Determine the number of millibars [mb] in 1 atm. **Remember**: The prefix "milli" means "1 one-thousandth".

7. The elevation of Mt. Everest is about 29,000 ft. above sea level. Express that number in kilometers.

8. The rate of decrease in temperature as you ascend in the lower layer of the atmosphere (the *troposphere*) is typically about 6.5°C/km. Express that rate of decrease in °F per 1000 feet.

9. The amount of energy per second per unit area which arrives at the top of the Earth's atmosphere is called the *solar constant.* Its value is 1370 watts/$m^2$. Express the solar constant in units of kilowatts per square meter (kw/$m^2$).

10. For electromagnetic radiation (i.e, including light), frequency (f) and wavelength (λ) are related to the speed of light (c) according to the formula:

    $c = \lambda f$

    If the wavelength of a beam of red laser light is $\lambda = 7.0*10^{-7}$meters, what is the corresponding frequency of the light? Frequency is expressed in units of inverse seconds (i.e, cycles/second). **Note: The speed of light is given in problem #3 above in units of km/sec. Be careful to solve the problem so that your calculations are performed using completely self-consistent physical units.**

## VI. Lab Discussion

1. Why is it important to use the correct units in physical science calculations?

2. Explain how the units used in physical geography are different from those we use in everyday life and why are they different.

Lab courtesy of Dr. Dana Kerola