GEOLOGY 306 Laboratory NAME: _____
Instructor: TERRY J. BOROUGHS

The Metric System, Measurements, and Scientific Inquiry (Chapter 24)

For this assignment you will require: a calculator & a metric ruler. Objectives: you should be able to list the units for length, mass, and volume that are used in the metric system and be able to use them for measurements. You should be able to understand the use of the micrometer and nanometer for measuring very small distances as well as the astronomical unit (AU) and light-year for measuring large distances. You should be able to determine the approximate density and specific gravity of a solid substance. You should also be able to conduct a scientific experiment using accepted methods of scientific inquiry.

THE FOLLOWING QUESTIONS REFER TO CHAPTER 24 IN YOUR MANUAL

Metric System Pre-Lab Video:

- https://mediaplayer.pearsoncmg.com/assets/secs-tarbuck8_prelab_video_23_metric

(Read the questions from your manual and place your answers in the following spaces provided.)

1. Use the metric conversion diagram, Figure 23.2 (8th edition) or Figure 24.2 (9th edition) (also included at the back of this packet), to convert the following or convert the following mathematically. Show your work and/or the movement of the decimal!

a. 310.52 meters (m) = _____ centimeters (cm)

b. 10.3545 meters (m) = _____ millimeters (mm)

c. 810.775 liters (l) = _____ deciliters (dl)

d. 0.45196 grams (g) = _____ milligrams (mg)

e. 16.2106 meters (m) = _____ kilometer (km)

f. 561829.1 centimeters (cm) = _____ meters (m)

g. 11365.548 grams = _____ kilogram (kg)

h. 918.2561 hectoliters = _____ dekaliters (dal)

2. Since we don't have enough meter-sticks to go around, just record your height in **inches** at this point and you will convert it to meters in question 7.

a. _____ Inches

3. Accurately measure the length of your **SHOE** to the nearest millimeter.

_____ (mm)

4. Use a metric ruler to measure the horizontal **Width** of your 306 lab manual or 305 text book (not the thickness of the table top!) as accurately as possible to the nearest tenth of a centimeter (called a millimeter):

_____ (cm)

5. Use a metric ruler to measure the **Length** of your 306 lab manual or 305 text book as accurately as possible to the nearest tenth of a centimeter (called a millimeter): then convert the length to each of the units in question 5b:

a. _____ (cm)

b. _____ (mm) _____ (m) _____ (km)

6. Observe all the people in the laboratory and pay particular attention to each individual's height and shoe length. **You should do this before you plot the data for the class!** Based upon your observations, write a tentative hypothesis or **prediction** that relates a **person's height** to their **shoe length:**

---

7. Previously in question 2 and 3 of this packet, each person in the laboratory recorded their height in inches. Convert your height into meters to the nearest hundredth of a meter. You will also gather height and shoe length data from the others in the laboratory. Enter their data below yours. If you need more space, make a second set of columns.

- **Your** height to the nearest hundredth of a meter.

- **Your** shoe length to the nearest millimeter.

• Height (meters)	Shoe Length (mm)
• Height (meters)	Shoe Length (mm)
• Height (meters)	Shoe Length (mm)
• Height (meters)	Shoe Length (mm)
• Height (meters)	Shoe Length (mm)
• Height (meters)	Shoe Length (mm)
• Height (meters)	Shoe Length (mm)
• Height (meters)	Shoe Length (mm)
• Height (meters)	Shoe Length (mm)
• Height (meters)	Shoe Length (mm)
• Height (meters)	Shoe Length (mm)
• Height (meters)	Shoe Length (mm)
• Height (meters)	Shoe Length (mm)
• Height (meters)	Shoe Length (mm)
• Height (meters)	Shoe Length (mm)
• Height (meters)	Shoe Length (mm)

Plot all of the above data on the Height vs. Shoe length graph, Figure 24.4 (9th edition) or Figure 23.3 (8th edition), by locating a person's height on the vertical axis and his or her shoe length on the horizontal axis. Then place a dot on the graph where the two intersect. **You do not have to submit the graph for credit,** but you will be answering questions based upon it!

8. Describe the pattern of the data points (dots) on the Height vs. Show Length graph, Figure 23.3 (8th edition) or Figure 24.4 (9th edition). For example, are the points scattered all over the graph or do they appear to follow a line or curve? Do they increase or decrease?

9. Draw and/or **observe** the single straight line on the graph that appears to average, or best fit, the pattern of the data points. You will need this information to answer the following question.

10. After observing the line on the graph, does the data indicate that as height increases, so does shoe length? (yes or no?)

11. Which do you think would be more accurate in predicting the height of a person, their **shoe length** or their **foot length**? (Pick one)

12. In light of the previous question, do you think that you should **modify** your original hypothesis to use foot length instead of shoe length? (yes or no?) **Give the reason(s) for your choice.**

13. Do you think that your ability to make predictions would have been more accurate and/or precise if you had used the heights and foot lengths of ten thousand people to construct your graph? **(yes or no?)**

By using the conversion tables on the inside back cover of your manual or **the last two pages of this packet** show the metric equivalent for each of the following units.

Length Conversion:

14. 1 centimeter = inch (in)

15. 1 foot = meter (m)

16. 1 kilometer = mile (mi)

Volume Conversion:

17. 1 liter = gallon

18. 1 cubic inch = $1in^3$ = cubic centimeter

Mass Conversion:

19. 1 ounce = gram

20. 1 kilogram = pound

Convert the following temperatures to their equivalents. Do the first four conversions using the appropriate equation, and the others using the temperature comparison scale on the inside-back cover of your manual. Equations**: [˚F = (1.8) ˚C + 32˚] or [˚C = (˚F – 32˚)/1.8]** When you want to convert degrees Celsius (°C) to Kelvins (K), delete the degree symbol and add 273. When you want to convert Kelvins (K) to degrees Celsius (°C), add the degree symbol and subtract 273.

21.

a. On a cold day it was 5˚F = ˚C

b. Ice melts at 0˚C = ˚F

c. Room Temperature is 72˚F = ˚C

d. A hot Summer day was 40˚C = ˚F

e. Normal body temperature is 98.6˚F = ˚C

f. A warm shower is 30˚C = ˚F

g. Hot soup is 70˚C = ˚F

h. Water boils at 212˚F = ˚C = K

22. Using the temperature comparison scale, answer the following.

a. The thermometer reads 35˚C. Will most people need a sweater?

b. The thermometer reads 8˚C. Will the outdoor swimming pool be open today?

c. If your body temperature is 36˚C, do you have a fever?

d. The temperature of a cup of cocoa is 25˚C. Will it burn your tongue?

e. Your bath water is 46˚C. Will you have a scalding, warm, or chilly bath?

f. “Who’s been monkeying with the thermostat? It’s 5˚C in this room.” Are you shivering or perspiring?

Use what you have learned about the metric system to determine whether or not the following statements are ***reasonable***. Write “yes” or “no” in the blanks. Do not convert these units to English equivalents, only estimate their value.

23. A typical adult man weighs approximately 400 Kilograms.

24. A fire hydrant is more than a meter tall.

25. A college student drank 1.0 kiloliters of coffee last night.

26. The room temperature is 2650 K.

27. A dime is 10 centimeters thick.

28. A large bag of sugar can be sold by the kilogram.

29. The temperature outside in Sacramento **today** is approximately 40˚C.

30. The bathtub has approximately 2800 liters of water in it.

31. You will need a sweater or coat if the outside temperature is 12˚C.

32. A pork roast or large loaf-sized block of tofu weighs 1.8 Kilograms.

By definition, one micrometer (μm) equals 0.000001 m (one millionth of a meter). There are one million micrometers (μm) in one meter and **10,000 micrometers (μm) in a centimeter.** A nanometer equals 0.000000001 m (one billionth of a meter), there are one billion nanometers in one meter.

33. There are (10, 100, 1,000) nanometers in a micrometer. Choose the correct answer.

34. What would be the length of a 8.5 centimeter line expressed in micrometers and nanometers?

- micrometers in a 8.5 cm line

- nanometers in a 8.5 cm line

35. Some forms of radiation (e.g. light) travel in very small waves with distances from crest to crest of about 0.5 micrometers (μm). How many of these waves would it take to equal nine centimeters? Hint: There are 10,000 micrometers (μm) in a centimeter, and each wave is ½ a micrometer long.

= Number of waves in 9 centimeters

The astronomical unit is a unit for measuring distances within the solar system. One astronomical unit (AU) is equal to the average distance of the Earth from the Sun. This average distance is 150 million kilometers, which is approximately equal to 93 million miles.

36. The planet Uranus is 2870 million kilometers from the Sun. How many AUs is Uranus from the Sun?

AUs from the Sun

The light-year is one unit for measuring distances to the stars and beyond. One light-year is defined as the distance that light travels in a vacuum in one year. This distance is about 6 trillion miles (6,000,000,000,000 miles).

37. Approximately how many miles will light travel in 15 years?

Miles for fifteen years

38. One of the brightest stars seen from Earth, excluding our Sun, is named Sirius. It is approximately 8.6 light-years away. What is the distance of Sirius from Earth in both miles and kilometers?

miles kilometers

Density is equal to the mass of a substance per unit volume, usually expressed in grams per cubic centimeter (g/cm^3) in the metric system. **Mass** is a measure of the amount of matter an object contains. **Weight** is a measure of the force of gravity on an object. For Example, the mass of an object would be the same on both the Earth and the Moon. However, because the gravitational force of the Moon is less than that of the Earth, the object would weigh less on the Moon. **On Earth, mass and weight are directly related, and often the same units are used to express each.** The **specific gravity** of a solid is the ratio of the mass of a given volume of the substance to the mass of an equal volume of some other substance taken as a standard (usually water at 4˚C). Because specific gravity is a ratio it is expressed as a pure number and has no units. For example, a specific gravity of 6 means that the substance has six times more mass than an equal volume of water. **Because the density of pure water at 4˚C is $1g/cm^3$, the specific gravity of a substance will be numerically equal to its density.**

One milliliter of water has a volume of approximately one cubic centimeter and one cubic centimeter or one milliliter of water has a mass of one gram.

39. Determine the density and specific gravity of a small rock sample using the data provided. Assume that your rock sample is 1225 grams and it displaces 125 ml of water. Use this information to answer parts C, D, E, & F of this question. Remember to show your work!

a. Mass of rock sample = 1225 grams

b. Volume of water that is displaced = 125 ml of water or cm^3 of water

c. Volume of rock sample = cm^3

d. Mass of water displaced by the rock = (g)

e. Density of rock = [mass of rock (g)] / [volume of rock (cm^3)] = g/cm^3

f. Specific gravity of rock = [mass or rock (g)] / [mass of water displaced by rock (g)] =

Complete the Summary/Report Page at the end of chapter 24 in your manual for extra credit. These questions are similar to the questions that you have already answered previously, so use the same techniques!

1. List the basic metric **unit** and **corresponding symbol** used for the following measurements.

- Length:
- Mass:
- Volume:

2. Convert the following units:

A. 361.8 liters = deciliters

B. 51621 millimeters = meter

C. 72°F = °C

D. 0.8156 kilograms = grams

E. 11.269 grams = milligrams

3. Indicate by answering "yes" or "no" whether or not the following statements are ***reasonable***:

A. A person is 1713.5 centimeters tall:

B. A bag of groceries weighs 215.0 kilograms:

C. It took 1210.0 liters of gasoline to fill a typical car's **empty** gasoline tank.

4. How many micrometers are there in 11.0 centimeters?

- Micrometers in 11.0 centimeters

5. How many waves, each 25 micrometers (μm) wide, would fit along a 12 centimeter line?

- Waves along a 12 centimeter line

6. What would be the distance of a star that is 118.5 light-years from Earth?

- Miles from Earth Kilometers from Earth

7. Neptune, one of the most distant planets, is 4497 million kilometers from the Sun. What is its distance from the Sun in astronomical units?

- Astronomical units from the Sun

8. Describe the difference between the two terms, **Density** and **Mass**.

Metric Prefixes and symbols

Prefix	Abbreviation	Meaning	Example	Number
Giga-	G	10^9	1 gigaliter = 1 x 10^9 liters	1,000,000,000
Mega-	M	10^6	1 megaton = 1 x 10^6 tons	1,000,000
Kilo-	k	10^3	1 kilogram (kg) =1 x 10^3 grams	1,000
Hecto-	h	10^2	1 hectoliter = 1 x 10^2 liters	100
Deka-	da	10^1	1 dekaliter = 1 X 10^1 liters	10
Deci-	d	10^{-1}	1 decimeter (dm) = 0.1m	0.1
Centi-	c	10^{-2}	1 centimeter (cm) = 0.01m	0.01
Milli-	m	10^{-3}	1 millimeter (mm) = 0.001m	0.001
Micro-	μ	10^{-6}	1 micrometer (μm) = 1 x 10^{-6}m	0.000001
Nano-	n	10^{-9}	1 nanometer (nm) = 1 x 10^{-9}m	0.000000001
Pico-	p	10^{-12}	1 picometer (pm) = 1 x 10^{-12}m	0.000000000001

Metric and English Units Compared

Units:

1 kilometer (km)	=	1000 meters (m)
1 meter (m)	=	100 centimeters (cm)
1 centimeter (cm)	=	0.39 inch (in.)
1 mile (mi)	=	5280 feet
1 foot (ft)	=	12 inches (in.)
1 inch (in.)	=	2.54 centimeters (cm)
1 square mile (mi2)	=	640 acres (a)
1 kilogram (kg)	=	1000 grams (g)
1 pound (lb)	=	16 ounces (oz)
1 fathom	=	6 feet (ft)

Conversions:

When you want to convert: multiply by: to find:

Length:

Inches	2.54	Centimeters
Centimeters	0.39	Inches
Feet	0.30	Meters
Meters	3.28	Feet
Yards	0.91	Meters
Meters	1.09	Yards
Miles	1.61	Kilometers
kilometers	0.62	miles

Conversions continued:

When you want to convert: multiply by: to find:

Area:

Square inches	6.45	Square centimeters
Square centimeters	0.15	Square inches
Square feet	0.09	Square meters
Square meters	10.76	Square feet
Square miles	2.59	Square kilometers
Square kilometers	0.39	Square miles

Masses and Weights:

Ounces	20.33	Grams
Grams	0.035	Ounces
Pounds	0.45	Kilograms
Kilograms	2.205	Pounds

Conversions continued:

When you want to convert: multiply by: to find:

Volume:

Cubic Inches	16.38	Cubic Centimeters
Cubic Centimeters	0.06	Cubic Inches
Cubic Feet	0.028	Cubic Meters
Cubic Meters	35.3	Cubic Feet
Cubic Miles	4.17	Cubic Kilometers
Cubic Kilometers	0.24	Cubic miles
Liters	1.06	Quarts
Liters	0.26	Gallons
Gallons	3.78	Liters

Temperature:

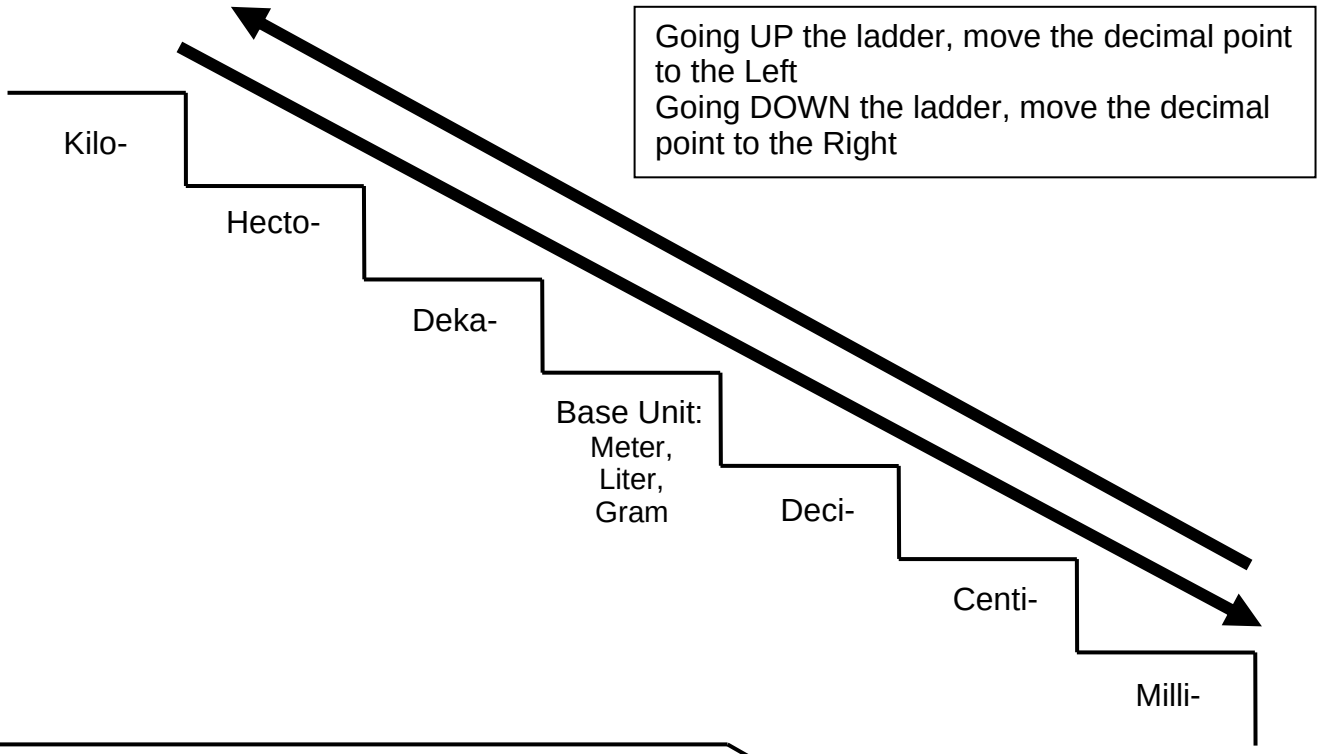
When you want to convert degrees Fahrenheit (°F) to degrees Celsius (°C), subtract 32 degrees and divide by 1.8.

When you want to convert degrees Celsius (°C) to degrees Fahrenheit (°F), multiply by 1.8 and add 32 degrees.

When you want to convert degrees Celsius (°C) to Kelvins (K), delete the degree symbol and add 273. When you want to convert Kelvins (K) to degrees Celsius (°C), add the degree symbol and subtract 273.

Examples of Scientific Notation

$10^0 = 1$ $10^1 = 10$ $10^2 = 100$ $10^3 = 1000$ $10^4 = 10000$ $2^0 = 1$ $2^1 = 2$ $2^4 = 2 \times 2 \times 2 \times 2 = 16$



This is a metric conversion diagram. The basic Metric units are Meters, Liters, and Grams. The prefixes indicate the position of the decimal point.

Beginning at the appropriate step, if going to larger units (left), move the decimal to the left once for each step crossed. For example, if two steps are crossed, such as moving from meters to hecto-meters, move the decimal two places to the left.

Beginning at the appropriate step, if going to smaller units (right), move the decimal to the right once for each step crossed. For example, if two steps are crossed, such as moving from meters to centi-meters, move the decimal two places to the right.

For example, 1.253 meters would be equivalent to 1,253.0 milli-meters