Student Name: ____________________ **GEOLOGY 101 LABORATORY** **Grade:**

Lab #1 - The Scientific Method and Units of Measurement

Introduction & Purpose: In this lab you will observe, measure, hypothesize, test, and analyze the materials and processes of a glitter lamp. The purpose of this lab is to become familiar with the basic tenets of the scientific method that geologists use to investigate the Earth.

ACTIVITY #1 – Scientific Inquiry – Apply Scientific Method to Study a Glitter Lamp

Scientists use a special sort of method to undertake all scientific inquiries - called the *scientific method*. The scientific method is a sequence of steps that include empirical observations, the formulation and testing of a hypothesis, or tentative explanation, which addresses the origin, evolution, nature and/or processes of natural phenomena.

Directions: Carefully study the glitter lamp that is set up in the lab; record observations and measurements concerning the material, energy, design, and processes of the lamp. Then address the following question: "What causes the glitter in the lamp to circulate?" Formulate a testable explanation or hypothesis – essentially the 'answer' to your question. Test your hypothesis by devising and running a test or experiment – the analysis of the observed results of your test or experiment should allow you to make the following conclusion: ***Yes*** – *my hypothesis is correct*, OR ***No*** – *my hypothesis is incorrect*. Be sure to include the following steps:

Step 1 - **Empirical Observations** - Qualitative & Quantitative descriptions and measurements of system:

a) Material Components– Describe, measure, and sketch (with labels) the whole and separate parts of the system. Include the following: size (height and width in centimeters); weight (grams); temperature (Celsius); material make-up of each component (examples of a component's material make-up are metal, plastic, glass, ceramic, wood, rubber, etc.); shape/form– it's "structure". Be careful here too to NOT INCLUDE any *explanations* or *interpretations* in your empirical observations – only descriptions and measurements of what you are actually observing.

b) Energy – Consider the sorts of energy that you detect in the system, including what may be going in or around the glitter lamp. Examples are electricity, light, heat, gravitational, kinetic, and magnetic. Be careful here too to NOT INCLUDE any *explanations* or *interpretations* in your empirical observations.

c) Movement/Dynamics/Temperature: Describe and measure notable changes/movement in the system: movement of material (glitter? fluid?) and energy, changes in radiant energy (heat and visible light). Note that a dynamic system indicates that there are processes occurring within the system and between the system and its surrounding environment. Some processes may be observable, whereas, others are not – depending on both, your own personal powers of observation and available sensing instruments. Movement of matter can be measured by rate of change. Heat can be measured by temperature (use Celsius). Again, be careful to NOT INCLUDE any explanations or interpretations in describing the system's dynamics.

Step 2 – Pose a Question about System: To better understand the system, a useful question about the system is proposed. The question should address something about the system that is of scientific noteworthiness. Note that questions that are answered by scientific investigation are firmly based on empirical observations (data) and rigorous testing using the scientific method and thinking.

Step 3 – Formulate a Working Hypothesis – Interpretation, explanation, and/or prediction of the system. Note that the hypothesis should be stated in a form that clearly answers the above posed question. A hypothesis may include predictions, based on the assumptions made in the hypothesis. A scientific hypothesis **must be falsifiable**; a hypothesis can be tested for validity within the empirical constructs of the natural world, i.e., the hypothesis is scientifically testable. Note that supernatural explanations are NOT testable.

Step 4 – Design a Test or Experiment – Create a definitive method/means of finding out whether or not your hypothesis is valid (true) or invalid (false). The test or experiment must be designed such that the ***test results*** (data) should provide a straight-forward ***test conclusion*** that is either a "**yes**" (validation) or "**no**" (invalidation) of your hypothesis (which addresses the posed question made in Step 1 above). Also, a test or experiment can be designed to address ***predictions*** (part of the hypothesis). Predictions specify a specific a state/change of/in the system that will occur ***in the future***, for a given set of (testing/experimental) conditions, based on your understanding (hypothesis) of the system. For example, you can make an educated prediction as to how the glitter lamp will behave in a certain way if you do a certain something to it while being tested by further observation.

Step 5 – Get the Results – Record your observations and measurements of your test or experiment as you perform the test or experiment on the system; you will be generating experimental ***data***. Analysis and evaluation of the data will lead to a conclusion concerning the hypothesis.

Step 6 – Come to a Conclusion – Make a statement that summarizes the evaluated results (data) from the test or experiment, in terms of addressing the validity of your hypothesis. Your conclusion ought to either refute (*invalidate)* the hypothesis and prediction(s), or confirm (*validate*) the hypothesis and predictions. It is possible that your results are inconclusive (neither a "yes" nor "no") – this result basically means that your test was inadequate, or that it poorly executed. In that case, reevaluation of your test design is a must.

Step 7 –Reevaluate and Retest the Hypothesis - Based on your conclusion, what must be done concerning your original hypothesis? Retain it? Modify it? Throw it out completely? Or does it appear that the test does not adequately challenge the hypothesis, and a new/improved type of test made? You also need to undertake/document a retest or new test of the system to further substantiate your hypothesis.

Step 1 – Qualitative (Descriptive) and Quantitative (Measurement) Observations of System:

a) Material and Structural Components (Draw sketches with adequate labeling of lamp components):
Include: 1) descriptive names for components; 2) linear (height & width) measurements; 3 mass; and 4) temperatures.

Complete System - (Sketch entire lamp) *Separated Components* - (Sketch each piece separately)

b) Movement/Heat: Describe the glitter movement pattern and note any temperature (heat) variations of system)

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Step 2 – Pre-Posed Question Concerning Nature of System:

"What causes the fluid/glitter to circulate inside the lamp?"

Step 3 – Tentative Hypothesis: Provide your best explanation for what causes fluid circulation in the lamp.

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Step 4 – Experiment/Test: Devise a simple experiment or testing procedure to test your hypothesis

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Make a Prediction: What do you think will occur during the test, based on your hypothesis? _____________

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Step 5 - Test Results: Write down your recorded test data (measurements/observations) here):

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Step 6 – Test Conclusion(s): Discuss how your test results line up with your hypothesis? Keep? Reject?

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Step 7 – Retest Your Hypothesis: Run another test to further test your hypothesis

Directions: Retest your hypothesis by doing your initial test in reverse. Write down the test results below.

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Step 8 – Post-Test Hypothesis Evaluation: Discuss how the retest results line up with your hypothesis.

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Step 9 – Hypothetical Thought Experiment on your Hypothesis: Try doing the following imaginary test

Directions: Imagine that you take the glitter jar and place it in an oven and heat the oven up to a temperature similar to that generated by the glitter lamp light bulb. **Question:** Once the glitter jar is heated up inside the oven, would the fluid and glitter start circulating like it does on the heated lamp base? Yes? or No? Briefly describe what you think the fluid will do, and why.

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ACTIVITY #2 – UNITS OF SCIENTIFIC MEASUREMENT AND UNIT CONVERSIONS

Metric Units of Measurement - The Science Units

Directions: Answer the following questions below concerning various aspects of measurement.

1) List four different metric units used for measuring **length/distances.** Units are abbreviated

km = _______________ m = _______________ cm = _______________ mm = _______________

2) List four different metric units used for measuring **area.** Hint: Abbreviations are provided

km^2 = ______________ ha = ______________ m^2 = _____________ cm^2 = _____________

3) List four different metric units used for measuring **volume.** Hint: Abbreviations are provided

m^3 = _______________ l = _______________ cm^3 = _______________ ml = _______________

4) List two different metric units used for measuring **mass.** Hint: Abbreviations are provided

kg = ______________________ gm = ____________________

5) List two different metric units used for measuring **temperature.** Hint: Abbreviations are provided

C = ______________________ K = ____________________

Unit Conversions

Directions: Complete the following unit conversions below. Use the unit conversion chart included in this worksheet.

LENGTH and DISTANCE (miles/yards/feet/inches vs. kilometers/meters/centimeters)

1) 3.0 mi = __________ km = _____________ m =_________________ cm

2) 137 km =_________ mi = _____________ft

3) 100 ft = ________ m =_____________ cm

4) Figure out your height in **meters** and **centimeters**. You'll first need to convert your height to decimal feet by converting the inches in your height to a decimal. For example, if you are 5 feet, 9 inches tall, that equals 5.75 feet, because 9 inches divided 12 inches/foot = 0.75 feet.

Your height: ________ft = ___________m = __________ cm

Mauna Loa Volcano on the Big Island of Hawaii

5) Mauna Loa is one of the largest volcanoes on Earth today, and sits on the seafloor in the middle of the North Pacific Ocean basin. Classified as a "shield" volcano, the edifice rises to 13,677 feet above sea level and constitutes half of the Big Island's area. Its dome is 75 miles long and 64 miles wide. This stupendous volcano sits over a hot spot and has been active for over 1 million years now since its inception on the deep seafloor.

a) What is the volcano's height (elevation) in meters? _______________ m

b) What is the volcano's length (how long) in kilometers? _______________ km

c) What is the volcano's width (how wide) in kilometers? _______________ km

The Grand Canyon in Arizona

6) The Grand Canyon averages 4,000 **feet** deep throughout its 277 **mile** length with an astounding 6,000 **foot** depth at its deepest point. Its width averages around 11 **miles** wide with a 15 **mile** diameter at its widest point. The bottom of this spectacular canyon exposes rocks as old as 1.8 billion years.

a) What is the canyon's depth (at its deepest point) in meters? _______________ m

b) What is the canyon's length (how long) in kilometers? _______________ km

c) What is the canyon's width (at its widest point) in kilometers? _______________ km

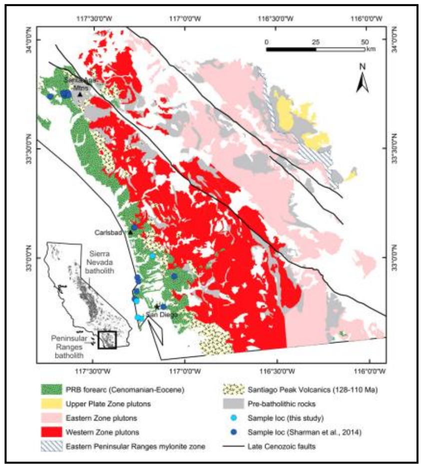
AREA (square miles/acres vs. square kilometers)

1) 20.0 km^2 = _____________ ha ?? = ______________ m^2 ? = ______________ acres ?

2) The **Peninsular Ranges Batholith (PRB)** covers a vast area of Southern California and Baja California which is comprised of hundreds of Mesozoic-age igneous intrusive bodies (crystallized mid-crustal magma chambers that are now exposed at the earth's surface). The PRB is roughly **1000** miles in length and roughly 100 miles in width.

b) How many **acres** are covered by the **PRB**? ____________________acres

c) How many **square** kilometers is the **PRB**? ______________________ km²



The Peninsular Ranges Batholith (PRB) in Southern and Baja California

VOLUME (gallons/quarts/ounces vs. liters and milliliters)

1) 3.0 gal = _____________ L =________________ mL or cm^3 Note: **milliliters (mL)** are the same as **cubic centimeters (cc or cm^3).**

2) 16.7 L = ____________gal =____________ qt

Uluru/Ayers Rock in Australia

Uluru/Ayers Rock rises 1,142 feet (348 meters) above the surrounding desert plain The monolith is roughly oval in shape, measuring 2.2 miles (3.6 km) long by 1.5 miles (2.4 km) wide

Length: 3.6 kilometers

Width: 2.4 kilometers

Height: 348 meters

Volume = Length x Width x Depth

Calculate the volume of the box in: **mL (milliliters)** and **L (liters)**

3) 3.6 km = ______ m   2.4 km = _______ m   348 m = _______ km

4) Volume of Uluru/Ayers Rock = _____ m x _____ m x ____ m = _______ m^3

5) Volume of Uluru/Ayers Rock = _____ km x _____ km x ____ km = _______ km^3

MASS (pounds/ounces vs. grams/ kilograms)

Mount Everest in Tibet

Mount Everest is the tallest mountain on Earth today (absolute elevation**)**, and quite massive. Located in the Himalayan Range of Nepal and Tibet, **Everest** has an estimated **weight** of 357 trillion pounds! Although this weight **does** include the rocks, it doesn't include the **weight** of ice and snow at the summit Note: 1 ton = 2000 pounds (lb) A metric ton = 1000 kilograms (Mg)

3) How much does Mount Everest weigh in tons? __________________tons

4) How much does Mount Everest weigh in metric tons? ______________________ Mg

World's Largest Rubellite (Tourmaline) Crystal (prof's favorite mineral)

The **biggest purple tourmaline (rubellite)** ever **found** weighs 374,000 carats or 2638.5 ounces.

5) How much does it weigh in **grams**? ___________ gm

6) How much does it weigh in **kilograms**? _________ kg

TEMPERATURE (Fahrenheit vs. Celsius)

2) The average temperature of erupting Hawaiian lava is around **1,200 degrees** Celsius.

What is the temperature in Fahrenheit? ______°F

Volcanic eruption of Kilauea crater, Hawaii

3) The average temperature of San Diego's Coastal surface water is **63**°F.

What is the temperature in Celsius? _______°C

San Diego's North County Coastal Waters

VELOCITY or RATE (Miles per hour/feet per second vs. kilometers per hour/meters per second

1) Imagine a hot glowing cloud of volcanic ash and gases rushing down the flank of an erupting volcano at over **50 miles per hour**. This phenomenon is called a pyroclastic flow, or **nuée ardente.**

A nuée ardente running down a volcano in Indonesia

What is the velocity of this dangerous ash flow in **kilometers per hour** and **meters per second**?

Nuée ardente velocity = 50 mi/hr = ______________ km/hr = _____________m/s

2) Hawaiian lava is very hot and mafic in composition, and it can flow at remarkably fast rates. Measured advance rates on the Island of Hawai'i are as **fast** as 5.8 mi per hour for an 'a'ā **flow** erupted from Mauna Loa in 1950, which **is** slightly slower than typical human jogging **speed**. Pāhoehoe **lava flows** typically move more slowly, less than a few hundred feet (or yards) per hour or day. What is the lava flow velocity in **meters per hour** and **meters per second**?

Mauna Loa lava flow rates = 5.8 mi/hr = ___________km/hr = _________ m/s

Lava Flowing down flank of Mauna Loa on the Big Island of Hawaii

ACTIVITY #3 - Scientific Method and Units Laboratory Reflection

Directions: Write a brief personal reflection of your lab experience learning about exploring the scientific method and doing unit analyses. (*3 points possible*).

Compose responses to the following 6-point question reflection set. When you are done, post your reflection on this forum by clicking on the curved "Reply" arrow.

1) What was the purpose of this isostasy lab? ____

____

2) *What did you actually discover and learn during this lab?* ______________________________

____

____

3) *What did you enjoy most about this isostasy lab?* ______________________________________

____

4) What was challenging or thought-provoking? ____

____

5) What are your constructive comments about the design and execution of this isostasy lab? What's good? What's bad?

____

____

6) How might this lab be improved? ____

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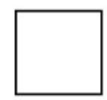
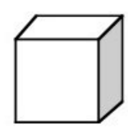
Units of Measurement and the Metric System

Quantity	Metric Unit	Symbol	Approximate Equivalents
	millimeter	**mm**	thickness of dime or paper clip wire
	centimeter	**cm**	width of a paper clip
Length	**meter**	**m**	1 yard or 3 feet height of door is about 2m
	kilometer	**km**	0.6 miles distance you can walk in 12 minutes
	square centimeter	**cm^2**	area of this space: 
Area	square meter	**m^2**	area of a card table top
	hectare	**ha**	area of a football field including end zones
	milliliter	**ml**	a teaspoon holds about 5 ml
Volume	**liter**	**L**	a quart
	cubic centimeter	**cm^3**	volume of this cube: 
	cubic meter	**m^3**	a cubic yard

Metric Unit Chart

MATHEMATICAL CONVERSIONS

To convert:	To:	Multiply by:	
kilometers (km)	meters (m)	1000 m/km	LENGTHS AND DISTANCES
	centimeters (cm)	100000 cm/km	
	miles (mi)	0.6214 mi/km	
	feet (ft)	3280.83 ft/km	
meters (m)	centimeters (cm)	100 cm/m	
	millimeters (mm)	1000 mm/m	
	feet (ft)	3.2808 ft/m	
	yards (yd)	1.0936 yd/m	
	inches (in.)	39.37 in./m	
	kilometers (km)	0.001 km/m	
	miles (mi)	0.0006214 mi/m	
centimeters (cm)	meters (m)	0.01 m/cm	
	millimeters (mm)	10 mm/cm	
	feet (ft)	0.0328 ft/cm	
	inches (in.)	0.3937 in./cm	
	micrometers (µm)*	10000 µm/cm	
millimeters (mm)	meters (m)	0.001 m/mm	
	centimeters (cm)	0.1 cm/mm	
	inches (in.)	0.03937 in./mm	
	micrometers (µm)*	1000 µm/mm	
	nanometers (nm)	1000000 nm/mm	
micrometers (µm)*	millimeters (mm)	0.001 mm/µm	
nanometers (nm)	millimeters (mm)	0.000001 mm/nm	
miles (mi)	kilometers (km)	1.609 km/mi	
	feet (ft)	5280 ft/mi	
	meters (m)	1609.34 m/mi	
feet (ft)	centimeters (cm)	30.48 cm/ft	
	meters (m)	0.3048 m/ft	
	inches (in.)	12 in./ft	
	miles (mi)	0.000189 mi/ft	
inches (in.)	centimeters (cm)	2.54 cm/in.	
	millimeters (mm)	25.4 mm/in.	
	micrometers (µm)*	25,400 µm/in.	
square miles (mi^2)	acres (a)	640 acres/mi^2	AREAS
	square km (km^2)	2.589988 km^2/mi^2	
square km (km^2)	square miles (mi^2)	0.3861 mi^2/km^2	
acres	square miles (mi^2)	0.001563 mi^2/acre	
	square km (km^2)	0.00405 km^2/acre	
gallons (gal)	liters (L)	3.78 L/gal	VOLUMES
fluid ounces (oz)	milliliters (mL)	30 mL/fluid oz	
milliliters (ml)	liters (L)	0.001 L/mL	
	cubic centimeters (cm^3)	1.000 cm^3/mL	
liters (L)	milliliters (mL)	1000 mL/L	
	cubic centimeters (cm^3)	1000 cm^3/mL	
	gallons (gal)	0.2646 gal/L	
	quarts (qt)	1.0582 qt/L	
	pints (pt)	2.1164 pt/L	
grams (g)	kilograms (kg)	0.001 kg/g	WEIGHTS AND MASSES
	pounds avdp. (lb)	0.002205 lb/g	
pounds avdp. (lb)	kilograms (kg)	0.4536 kg/lb	
kilograms (kg)	pounds avdp. (lb)	2.2046 lb/kg	

To convert from degrees Fahrenheit (°F) to degrees Celsius (°C), subtract 32 degrees and then divide by 1.8
To convert from degrees Celsius (°C) to degrees Fahrenheit (°F), multiply by 1.8 and then add 32 degrees.

*Formerly called microns

Unit Conversion Chart