Name: ________________________ **Class:** ______________________ **Grade:** _____

OCEA101 Laboratory - Introduction to the Scientific Method

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 oceanographers use to investigate the world ocean.

Exercise #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?"

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

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<u>Step 4 – Experiment/Test</u>: 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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<u>Step 5 - Test Results</u>: Write down your recorded test data (measurements/observations) here):

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

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<u>Step 7 – Retest Your Hypothesis:</u> 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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<u>Step 8 – Post-Test Hypothesis Evaluation:</u> Discuss how the retest results line up with your hypothesis.

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<u>Step 9 – Hypothetical Thought Experiment on your Hypothesis</u>: 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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EXERCISE #2 – CONVERTING UNITS OF MEASUREMENT

Directions: Calculate the following unit conversions using the correct significant place values. The unit conversion values are found on the last age of this worksheet. Note that you **MUST** show your *math calculation* (to the right of problem) **AND** *units* to get credit for your answer.

Unit Conversion Problem	Unit Conversion Calculation Here
Example: 2.5 miles = _4.0_ kilometers	Example: *2.5 mi x 1.61 km/mi = 4.03 km*

a. 10.00 miles = _______ kilometers.

b. 3.0 feet = ______ meters.

c. 16 kilometers = ______ meters.

d. 25 meters = ______ centimeters (cm).

e. 1.3 liters (L) = ______ milliliters (mL) or cubic cm (cm^3)

f. 2.68 ounces = ______ grams

g. 73 degree Fahrenheit = __________ degrees Celsius.

h. An ocean wave travels 25 miles an hour in deep water. The speed of the wave = _____ km/hr

i. An ocean current traveled 2.8 meters in exactly 1 minute. The current flow speed is ______ km/hr

EXERCISE #3 - Written Laboratory Reflection

Directions: Write a reflection of the lab activity, explaining its purpose, the methods used, the results obtained, and a brief personal reflection of what you enjoyed and learned about doing this lab. A complete reflection should use up all the space provided below. This reflection is worth 2 points.

1) What did you actually discover and learn during this lab about the scientific method?

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2) What did you enjoy most about this lab? Also, what was challenging or thought-provoking?

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