Lab 1 – The Scientific Method

INTRODUCTION

The following laboratory exercise is designed to give you, the student, an opportunity to explore unknown systems, or “universes,” and hypothesize possible “rules” which may govern the behavior within them.

Scientific Method

There are many different scientific methods. They are all similar in their shared use of careful, deductive reasoning. We will use the following version of the Scientific Method:

- Observation – recognize a phenomenon
- Hypothesis – propose an explanation and predict its consequences
- Experiment – devise a test to determine the validity of your hypothesis
- Analysis – compare results with hypothesis, re-test to check for error
- Conclusion – what you learn from experiment and hypothesis

Hypothesis

The essence of the scientific method lies in the hypothesis. Hypothesis can be defined as an “educated guess; a reasonable explanation of an observation or experimental result...tested...by experiment.” A good hypothesis must meet three criteria. First, it must be simple and apply to the phenomena in question. This is known as Validity. Second, it must be testable, that is, repeated experimentation must be able to confirm or disprove it. The ability to be disproven is a subtle, yet important point. For a hypothesis to be scientific it must be falsifiable. Third, a good hypothesis must be able to predict the outcome of future experiments or predict the existence of as-yet-unobserved phenomena.

PROCEDURE

Part A: The Hypothesis Machine

The hypothesis machine is a device that consists of a series of channels within a plastic casing. In the center of the casing, there is a covered section with a space to insert various shaped blocks. The various shaped blocks are hidden from view, and depending on the shape and position of the block, balls that roll down the channels can be stopped or have the path of their motion changed by the block.

The object of the experiment is to make a hypothesis about the shape and position of the block in the hidden area based on the behavior of steel balls that are dropped through.
Discuss with your group members what makes a good hypothesis. What would be a good hypothesis for this demonstration? What factors could cause a change in the path of the motion of the ball? Are these likely possibilities? Why? Why not?

Your laboratory instructor will set up the machine and drop the balls, one at a time. Your instructor will do this for three different shaped blocks. As the instructor drops the balls, the class will discuss possible shapes. As the class does this part of the exercise, take careful notes and answer the questions on the worksheet at the end of this document. Here are some questions you might want to consider to help in your decision making process.

1. What happens to each ball as it goes through the machine?
2. What factors do you consider while hypothesizing about the shape?
3. What conclusions do you draw about each shape? What features of the paths would you use as basis for your conclusions?
4. Were your conclusions about each shape correct? If not, why?

CHECKPOINT 1: HAVE YOUR TA CHECK YOUR WORK BEFORE PROCEEDING

Part B: The Checkerboard Investigation

Each universe consists of the same basic “system”, which is a checkerboard, some red and black checkers, and a set of “allowed configurations” (a set of possible checker placements). Work in groups of approximately four students try to discover the rules which determine these configurations; that is, under what circumstances and in which squares can the checkers be placed according to the rules of the universe.

For each checkerboard universe you explore, choose one person from your group to represent the universe. This representative will be given the rules of the universe, and will be in charge of the checkers. This student’s job will be to tell the others whether a particular checker is allowed, by the rules of the universe, in a particular space. The other three members of the group will take turns placing checkers.

Each time a checker is placed on the board, the representative will declare it as either “allowed,” or “not allowed,” according to the rules of the universe. If a checker placement is allowed, it is left on the board. If it is not allowed, the checker is removed from the board.

From the results of these placements, your team will have to hypothesize rules for the universe. When your team feels that it has come up with a rule that correctly predicts the allowed and disallowed placements, submit it in writing to the representative. For a hypothesis to be valid, it should be written down on paper.
If it is correct, you may go on to the next universe. If the hypothesis is correct but incomplete, or if it is incorrect, the representative should say so and you must continue to explore until the entire rule is determined. You will not be penalized for making incorrect hypotheses. As you explore each universe, take careful notes and answer the questions on the worksheet at the end of this document.

Your notes should include:

- the universe’s number
- description of the placements you tried in the order they were tried
- your strategy behind each placement or sample set of placements to test a possible rule in the universe
- each hypothesis made (correct, incorrect, or partially correct)
- The “final” correct hypothesis

Explore a total of ten universes. Choose a new representative each time you go to a new universe. When you are the universe representative, be very careful in judging whether a move is allowed or not. If you make a mistake, it could make things very confusing for the team, and you may have to start all over with that universe. If you are unsure of a placement, or an entire rule, consult with your laboratory instructor before answering. If you have to start over because the representative made a mistake, do not count that universe. If you start to run out of room on your checkerboard before determining the correct rule, you can start the universe over.

If you have time after completing the ten assigned universes, have each member of the group take a turn as the representative and make up rules for a new universe. Make the rules as original and as crazy as possible. Observe how long it takes for other members of the group to deduce the rules.

CHECKPOINT 2: HAVE YOUR TA CHECK YOUR WORK BEFORE PROCEEDING
**SCIENTIFIC METHOD - WORKSHEET**

**Part A: The Hypothesis Machine**

Answer the following questions for three of the blocks you investigated.

**Block 1:**

1. What happens to each ball as it goes through the machine?

2. What factor(s) did you consider while hypothesizing about the shape of the block?

3. What features of the path of each ball helped you in your decision making process?

4. What conclusion did you draw about the shape of block 1?

**Block 2:**

1. What happens to each ball as it goes through the machine?

2. What factor(s) did you consider while hypothesizing about the shape of the block?

3. What features of the path of each ball helped you in your decision making process?

4. What conclusion did you draw about the shape of block 1?
Block 3:

1. What happens to each ball as it goes through the machine?

2. What factor(s) did you consider while hypothesizing about the shape of the block?

3. What features of the path of each ball helped you in your decision making process?

4. What conclusion did you draw about the shape of block 1?

Part B: The Checkerboard Investigation

Report your observations for three out of the ten Universes you investigated in the space provided below. For each report make sure you address the following points.

(a) the universe's number

(b) description of the placements you tried in the order they were tried

(c) the strategies you adopted for the placement of the checkers

(d) the correct (or incorrect) hypothesis you made

(e) the "final" correct hypothesis.
Universe 1:

Universe 2:

Universe 3:

CHECKPOINT 2