Key terms for understanding Oregon’s Scientific Inquiry and Engineering Design Scoring Guides

Refers to “Walking Snails” and “Water Filter” Samples

Science Inquiry

- **Alternatives** – Two or more mutually exclusive possibilities. In a scientific inquiry there may be more than one way to investigate or think about a phenomenon. Finding alternative hypotheses or experimental methods can help students to think critically about their inquiry. An alternative investigation can be seen in the final paragraph of the student snail example below where the student considers two different questions that could lead to different investigations of how surfaces affect the mobility of snails.
- **Analysis** – The process of organizing and manipulating information or data in order to draw conclusions. Analysis frequently includes making calculations and graphs of the data and looking for patterns or trends that can be used as either supporting or refuting evidence. Analysis in the student snail example below includes the calculation of average distance and average speed from recorded data and the graph that presents the calculated speed in an easy to read format.
- **Claims** – A statement of knowledge supported by thought, analysis, and/or data. In the snail student work sample the claim was made that snails move faster on smooth surfaces because there is less friction. (This is not scientifically accurate, but is supported by the student’s investigation.)
- **Communication** – The process of clearly conveying an idea or set of ideas from one person to another. In scientific inquiry the results and findings of the inquiry are communicated. The student written report of her investigation is a good example of this kind of communication.
- **Conclusion** – Summary of knowledge gained during an inquiry presented at the end of a report or presentation. The conclusion should restate the hypothesis and include a discussion of how the results support or refute the hypothesis and/or claim(s).
- **Control** – A set of variables that are identified as having a possible affect on experimental results which are kept constant during an experiment. Good use of experimental control allows for more meaningful comparisons between changes in the independent variable and the dependent variable. The student snail example below, there are several controls: time, snail features (e.g. size, species, temperature, and snail moisture).
- **Data collection** – The process of gathering information that is relevant to an investigation. In the student example below, the student collected data measuring how far the snail traveled in a minute.
- **Dependent variable** – Is a variable which is expected to change when the independent variable is changed. The value of the dependent variable can be said to depend on the independent variable. The hypothesis will almost always include a relationship between the independent and dependent variables. In the student example below, the distance the snail travels is the dependent variable. (See also: independent variable, variables)

- **Empirical** – Facts or knowledge that are based on observation rather than opinion. The reliance on empirical facts is one of the main features of science that is different from other disciplines.
- **Evidence** – Information or data that can be used to support or refute a hypothesis or claim. In the student snail project below, the analyzed data showed evidence that snails move faster on wood than other surfaces tested. Evidence is not proof.
- **Extrapolation** – A process of using existing data or knowledge to speculate a result beyond the range of the data. Though not always reliable, extrapolation is a useful process when data appears to show a trend. For example, the student's investigation concludes that there is a trend between increasing snail speed and smooth surfaces. The student might extrapolate that the snail will move with increased speed on an even smoother surface.
- **Field study** – An investigation that is carried out where the subject being investigated is naturally found. The student snail example below is not an example of a field study because the snail was not observed in its natural environment.
- **Humane** – Ethical consideration so that the subjects of a study are not unnecessarily harmed. The student snail example below is an example of a humane study because neither a person nor the snail was harmed in the process. The alternative of investigating how much mass a snail can pull across different surfaces may have led to an inhumane investigation.
- **Hypothesis** – An informed testable statement about how something may behave or relate that is specific to the investigation, stated clearly, and can be tested by scientific inquiry. The hypothesis in the student snail example below is stated "I think the snail will travel the fastest on the glass and linoleum. I think it will travel the slowest on the wood, grass, and cement."
- **Implications** – Relationships between variables or phenomena that are implied by data, other knowledge, and reasoning. Implications are useful for providing direction for future studies. In the student snail example below the student implies that the smoothness of the surface has a positive effect on how fast the snail moves.
- **Independent variable** – Is a variable that is intentionally changed during an investigation. Based on the hypothesis, a change in the independent variable is expected to result in a measurable change in the dependent variable. In the student snail example below the independent variable was the type of surface upon which the snail moved. (See dependent variable, variable)
- **Investigation** – The process of methodologically studying some thing or some relationship to answer a question. In a scientific investigation there may be a series of experiments that that are designed to improve understanding or generate evidence. The student snail example below is an investigation with one experiment and results in a knowledge claim about the relationship of surfaces and snail mobility.
- **Logical** – A reasonable or sound line of thinking. Based on the student's results and her concept of how much friction one surface offered versus another, it was logical for her to conclude that the snail traveled slower on rough surfaces because of increased friction. (Though logical, this conclusion is not scientifically accurate.)

- **Manipulation** – Intentional, often manual, change of position or properties during an experiment. The student in the below example manipulated the snail by placing it on the different surfaces.
- **Multiple trials** – The practice of repeating an experiment, or a series of experimental steps, multiple times. Multiple trials are performed to obtain data after manipulating the independent variable or to demonstrate the repeatability of experimental results. In the student snail example below, multiple trials were performed three times for each surface type and those trials were repeated five times, once for each surface material.
- **Observation** – The process of carefully watching and recording events and processes through the course of an experiment or inquiry. In the student snail example below, in addition to observing the distance the snail traveled, the student made observations about changes in snail performance. This is especially important when things happen during an experiment that may have an effect on the data.
- **Prediction** – An informed statement about the results of an experiment often included with the hypothesis. In the example below, the student predicts upon which surfaces the snail will travel the fastest.
- **Principles** – Primary concepts that are fundamental to the formation of theories and hypotheses. In the "background" section of the student example below, principles are considered with respect to assumptions and understandings about how snails behave, live, and move. These principles help focus the design of the experiment.
- **Probability** – A formal evaluation of how likely a result will happen again. In the student example below, the probability that the snail would move in the same way, given the same set of conditions, is indirectly addressed in the conclusions. The low probability that the snail would move the same every trial has an impact on the repeatability and reproducibility of the results.
- **Procedure** – An ordered list of instructions for an investigation that guide the process of the experiments and data collection. As a rule of thumb, the procedure needs to have sufficient detail so that future investigators could conduct the same investigation. In the example below the student provides a list of steps in order that guided her data collection.
- **Repeatability** – An important characteristic of a scientific investigation is that the same experiment can be repeated using the same methods. Communication is an important part of repeatability. When the results of an investigation are communicated there should be sufficient detail so that another investigator could repeat the investigation. In the student example below, there are missing details about how the snail was systematically manipulated which would make the experiment difficult to repeat.

- **Reproducibility** – An important characteristic of a scientific investigation is that the results can be reproduced using different methods to investigate the same subject. The results of an investigation are considered more and more valid as other scientists are able to reproduce, or replicate, an investigation and have comparable results. The student example below might be reproduced by another student using a similar method while changing one or more steps in the procedure or changing which variables are dependent, independent, or control. For example another student might use the same surface material for all trials and run the same experiment to see if the snail got "tired" and then compare the results to see if the snail being tired affected the results of the original study.
- **Safety** – Wise consideration to avoid harm to people or property. When an investigation is being designed, the investigator should consider what could happen that might be a safety issue.
- **Source of error** – A process or event that was not systematically followed, or an unforeseen occurrence, that may have affected the data or results. In the student snail example below many sources of uncertainty were discussed in the "Review Your Design" section.
- **Systematic** – A practice or process that is followed step by step. When conducting an investigation, it is important to be systematic so that the process is repeatable and the results of one trial are comparable with another trial. The student in the example below the student discusses some steps that were not systematic to her procedure that may have affected the results of her investigation.
- **Theory** – An idea or group of ideas that provides a framework from which hypotheses can be derived. Scientific theories attempt to explain how the world works. The theory supporting the student snail example is that the environment the snail is in, at any given moment, affects the snail.
- **Uncertainty** – The degree to which a measurement or calculation may be in error due to measurement tools or other circumstances within an experiment. A common source of uncertainty is the smallest degree of measurement a measuring instrument can make. For example if the smallest mark on a ruler is a millimeter, then the range uncertainty for any measurement using that ruler will be plus or minus half a millimeter (+/-0.5mm). In the student example there is no discussion of uncertainty. However, it appears that 0.1 cm was the smallest unit of measurement. If that is the case, the student should have included a range of uncertainty of +/-0.05cm.
- **Validity** – A characteristic of a study or measurement indicating it is accurate and well supported. A study is valid if it is logically sound, has reproducibility, and really reports on the subject it claims to study. The student snail example below demonstrates some aspects of validity. It is logical that surface type might affect how a snail moves. And the hypothesis, procedure, data, and explanation are all focused on the same ideas. While the study may be reproducible, it is not said to have reproducibility until the results are replicated or reproduced.
- **Variable** – A property or feature that can change. Most variables can be measured or be described in a simple statement. Variables are used in science to describe parts of a system within an experiment and how the parts might relate to each other. In the student snail example below, there are many variables identified: distance, time, type of snail, temperature, snail moisture, type of surface. Distance was measured in cm. Time was measured in seconds. Surface type was described as 'glass', 'wood', etc.

Engineering Design

- **Assembly** – An object that is put together using a design and components listed in the design Bill of Materials. An assembly can be the whole product or can be a part of the whole product often called a sub-assembly. In the Water Filter example, the filter will be made up of many parts assembled per the design. This is an assembly. The inverted 2-liter bottle and base that all the students use could be considered a sub-assembly.
- **Bill of Materials** (BOM) – A complete list of all the parts required to build an assembly. Often times a BOM includes the cost of the parts.
- **Component** – A required part used to build an assembly or sub-assembly. If a student uses a screen as part of their design, the screen is a component of the design.
- **Constraints** – Are rules that define the maximum limit of a particular characteristic of a design. A constraint in the water filter example might be that the filter must fit within the 2-liter bottle canister.
- **Cost-benefit** – A method of analysis that compares costs versus the benefits of a design. Cost benefit is a criterion for the Water Filter example which is scored and balanced against other performance criteria.
- **Criteria** – The outcomes that determine whether a design successfully solves the problem. The criteria for the Water Filter example are Color of Water, Cost, and Speed.
- **Data –** Information collected that is useful as evidence of how well the design achieves, or is expected to achieve, the criteria of success. Data can be both numerical (quantitative) or descriptive in other qualitative ways. Measurements of elapsed time will provide quantitative data for the Water Filter example. Determining the water color may be qualitative data that shows to what extent the water was filtered.
- **Design** (noun) – A plan for a product, process, or system that is devised to solve a problem. The diagrams, BOM, and hopefully assembly instructions will represent the design of a Water Filter.
- **Design** (verb) — The process of modifying or inventing a product, process, or system to solve a problem. While designing the Water Filter, students will work through the process, deciding what design of Water Filter will solve the problem and meet the criteria.
- **Failure** – A condition or event where the design fails to meet the criteria of success. If a student's water filter breaks when water is poured too quickly into the filter such that it leaks unfiltered water, this would be a failure condition.
- **Fatigue** – Failure of a component caused by repeated stress. Usually fatigue is considered when the component failed because the material the component is made out of failed. A common example of this is breaking a paper clip into two pieces by bending it back and forth multiple times.
- **Format** – The state or display of data that is chosen during analysis. Format choices should attempt to make the evidence supported by data clear and easy to read. This may simply be organizing the data into a table, graphs, or other options to present the data. The Water Filter activity includes a preformatted worksheet to help students present their data using a predetermined scoring process.

- **Feasible** – The characteristic that something is possible given the laws of nature and probability. The Water Filter example is a very feasible project. The materials are readily available and it relies on the characteristics of the materials and gravity. A project that is not feasible, given the extent of our current knowledge, might be a time travel device or a perpetual energy machine.
- **Feasibility Test** -- A preliminary test using a simple model of a design as a reality check to see if the design is likely to solve a problem.
- **Function** – The intended purpose or use of a design. The function of the Water Filter is to filter out several contaminates from water.
- **Human Error** – Failure caused by human action during the operation or testing of a design, either intended or unintended. Errors in the assembly process may be considered human error, but only if the assembly instructions have enough detail that the error should not have happened if the instructions were followed.
- **Innovation** – A new or improved means to solve a problem. The Water Filter example is not likely to present much in the way of innovation, since the materials available have all been used in similar applications.
- **Instrumentation** – The device(s) used for measurement or control during the testing or operation of a design. A stop watch to measure filtration time will be a necessary part of the instrumentation for the Water Filter example.
- **Invention** – The first occurrence of a new technology designed to solve a problem or meet a need. Invention is closely related to innovation. An invention often indicates an intent to market the product or to protect the intellectual property with a patent or other process.
- **Load** – The force against which something must do work. In the Water Filter example, the filter materials provide a frictional load that the water has to flow through, work.
- **Materials** – Substances or components used in a design. Often materials are considered with respect to their physical and chemical properties. In the Water Filter example, the screen is a material with several properties including the size of the openings allowing only small objects to pass through.
- **Mechanical** – A device, tool, or machine that moves in space. While not a typical machine, the Water Filter includes hydraulic design principles which are considered a part of the Mechanical Engineering discipline. In this example, water is the moving part. In an electrical circuit is not considered a mechanical system, though electrons are thought to move through it. However, switches are often mechanical components in an electrical circuit.
- **Model** – 1. An object that represents a design. It may function like the design or represent the size and shape of the designed object, or be a graphical representation (e.g. a scale drawing) of an object or a process. The Water Filter example could be considered a model building exercise that is intended to quickly figure out the best materials and sequences to make a good filter. The model in this case would help the designer know what to consider as they worked to a more final design.

Model- (continued)

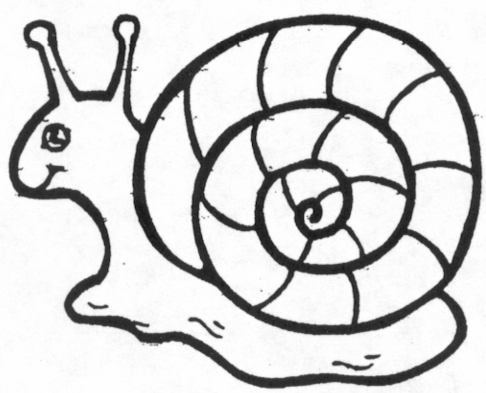
2. A simulation of a design using a system of equations or other abstract ideas to represent how the design is intended to function. Skills making models like these are highly desirable since these models cost very little money to make and test. However, these models require a great deal of knowledge about the laws of nature and the properties of the materials that are intended to be used. In the Water Filter example, students could be provided with additional information about how water flows through the different materials, equations, flow rate and viscosity data. Using that information, they could make a mathematical model about how long their design will take to filter the water.

- **Modifications** – Changes to a design that are intended to improve performance. Making modifications to a design is a normal step in the design process since the first design is almost never perfect. In the Water Filter example students are prompted to create multiple designs. Though modifications often follow testing, modifications are also done as designs are refined before a model is made and testing begins. A student might modify their water filter design to include more or less of a filtering material to improve time or quality of filtration.
- **Needs assessment** – A process for determining needs or gaps between the current and desired condition. If a student's water filter was unable to filter one of the contaminants, they would have identified a condition that their next design would need to address.
- **Operational** – The characteristic of a device to carry out an intended function. If a student's water filter is able to filter the water within the design criteria, it would be considered operational.
- **Optimization** – The process of considering design tradeoffs in order to maximize performance with respect to a criterion or prioritized list of criteria. Optimization is often a goal of the modification process (see "Modifications"). If a student intends to add more filter material to their design to improve the quality of filtration it will likely have a negative effect on the time score.
- **Practical** – The characteristic that a problem or solution has a real world application. The Water Filter example below is a realistic and practical problem if you were trying to make a simple cheap water filter.
- **Priorities** – A ranking of criteria in their order of importance. In the Water Filter example, the priorities are indicated by the scoring system. For example a design this cheap to make is worth more points than a design that filters water quickly.
- **Problem** – A situation requiring a solution, often defined in terms of criteria and constraints. The problem in the Water Filter example is to filter many contaminants efficiently, quickly, and cheaply.
- **Prototype** – A first working model of a design which is usually constructed to test performance such as in a feasibility test. The first water filter the students build will be a prototype.

- **Risk** – 1. Source of hazard or danger. In the water filter example, the sharp edge of the 2-liter bottle might be a safety risk.
  2. Challenge or obstacle that can delay or prevent successful completion of a project. If one of the materials has not arrived before the Water Filter exercise has begun, there is a risk that students will not be able to build a successful prototype.
- **Safety factor** – Increase in design specifications to minimize harm to people in case of a failure event, sometimes expressed as a ratio such as designed strength divided by expected load. Determining the safety factor helps decide how serious of a risk a failure would be. In general it is a good idea to have safeguards in place to minimize risk of injury or harm.
- **Scale** – 1. Tool for measuring a physical property (ex. A ruler or mass balance.)
  2. A ratio indicating size difference between a model or drawing and the proposed real size of a design. Scale is commonly written '1: x'. (ex. "scale 1:5" on a drawing means 1" on paper is 5" in real space.)
- **To Scale** – A method for designing or building a smaller or larger model of a design solution where all components are sized according to a given scale ratio, see scale.
- **Solution** – A process or device that solves a stated problem. A water filter that meets the criteria for quality and time of filtration within cost constraints is a solution to the water filter problem.
- **Stress** – A measurement of force within an object per unit area. Usually used to calculate what external forces will cause a failure condition. If there is too much material in the water filter, it may put too much stress on the filter body and result in a rupture.
- **Structural** – Related to shapes and relationships of physical elements in a body. Often refers to components or elements of a design that are load-bearing, or support, the structure such that the structure might collapse, if removed or fails. The 2-liter bottle is an important structural component fo the water filter.
- **System** – A collection of interrelated components that make up a whole. Often used when there are more than one type of component, like mechanical and electronic components, working together.
- **Technology** – A product, process or system devised to solve a problem, meet a need, or fulfill a desire. Technology can be very simple and require little sophistication, or low tech. Or it can be very complicated and/or require a great deal of sophistication to achieve, or high tech. The water filter example is a low tech solution.
- **Testing** – The process of investigating a solution to see if it meets the criteria and constraints of the problem it was designed to solve. Testing usually requires a systematic process and careful observation to be valid. The water filter is tested using different 'dirty water' sources as well as observing and recording the elapsed time required to filter a ½ cup of water.

- **Tolerance** – Allowable range of error. No components are perfect in the real world. A mechanical part can only be fabricated within the constraints of the machine or technician making it. Electronics components have the same kind of limitation. Tolerances are usually expressed as a either a range or percentage of acceptable deviation from the ideal value. While creating a design, it is important to consider these limitations and evaluate the cost-benefit of components with large or small deviations, low or high tolerances respectively. In the water filter example, the lid and 2-liter bottle must have sufficiently high tolerances to make a seal, but low enough tolerances to make the components cost effective.
- **Trade-off** – A design decision in which one desirable characteristic is chosen at the expense of another. In the water filter example, while considering the filtering properties of different materials, a student might decide to use less of one material to make room for another.

Walking Snails



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Framing the Investigation

Organism: Land Snail (Helix)

Manipulated/Independent Variable	Responding/Dependent Variable
Surfaces	Speed of the Snail (cm/sec)

Explain how you will measure your manipulated and responding variables:

We will use a stopwatch and a ruler to measure how fast a snail will travel in 60 sec on glass, grass, linoleum, cement, and wood.

Other variables which could affect the responding/dependent variable:	How you will control these variables:
1) Time	1) We will use a stopwatch to time the snail for sixty seconds.
2) Snail	2) We will use the same snail.
3) Surface	3) For each trial, we will use the same spot on the surface.
4) Temperature	4) We will try to keep the temperature the same by doing the surfaces all on the same day.
5) Moisture of Snail	5) We will spray the snail once before each trial with the same water bottle.

Question:

How do different surfaces affect the speed that a snail travels?

Hypothesis:

I think that the snail will travel the fastest on the glass and linoleum. I think it will travel the slowest on the wood, grass, and cement.

Background Information:

- The land snail lives in the dirt and grass.
- It is nocturnal, and since the experiments will be done in the day, it may not move as fast as it would at night.
- Speed = Distance / Time
- Snails produce a sort of slime that they use to help them "glide" along surfaces.
- Snails eat fruits, leaves, and grass, so it may have a small snack when it is in the grass.
- Smooth surfaces such as linoleum and glass produce less friction then rough surfaces such as wood, grass, and cement.

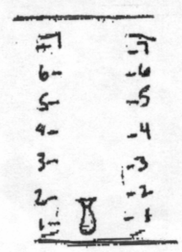
Designing the Investigation

Materials:

2 Meter-sticks
2 Petrie dishes
1 Snail
1 Stopwatch
1 Spray Bottle with water in it
Lettuce
Linoleum
Grass
Wood
Glass
Cement
Pencil and Paper
Calculator

Illustrations:

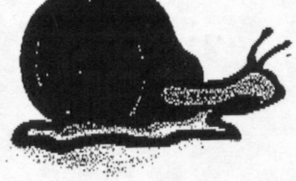
(2)



(4)

Procedures:

1) Find a snail and place it in one of the Petrie dishes and then place the other dish on top of that dish, enclosing the snail so it cannot escape.
2) Find a level place on a piece of wood. Place the two meter-sticks parallel to each other a couple inches apart on the wood. Make sure the centimeter side is up.
3) Place a piece of lettuce towards the end of the meter sticks as motivation for the snail to move
4) Next, take the top Petrie dish off, squirt the snail once with a water bottle, and gently place snail on the wood at the beginning of the meter-sticks. Make sure the end of the snail's shell is at the zero mark on the meter-sticks.
5) Immediately start the stopwatch and use it to time sixty seconds while the snail moves along the wood.
6) At the end of sixty seconds, see where the end of the snail's shell is along the meter stick, and record the distance on a piece of paper. Place the snail back between the two Petrie dishes while you are recording your results.
7) Repeat steps three through six two more times.
8) Repeat steps two through seven with except on grass, then linoleum, then glass, and finally cement.
9) Place the snail back where you found it so it can live the rest of its life in its home.
10) Find the averages of the distance the snail traveled on each surface.
11) Then, to find the speed the snail moved, use a calculator to divide the average distance by the time (sixty seconds). The end result is the speed the snail moved in centimeters per second.



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Collecting and Presenting Data

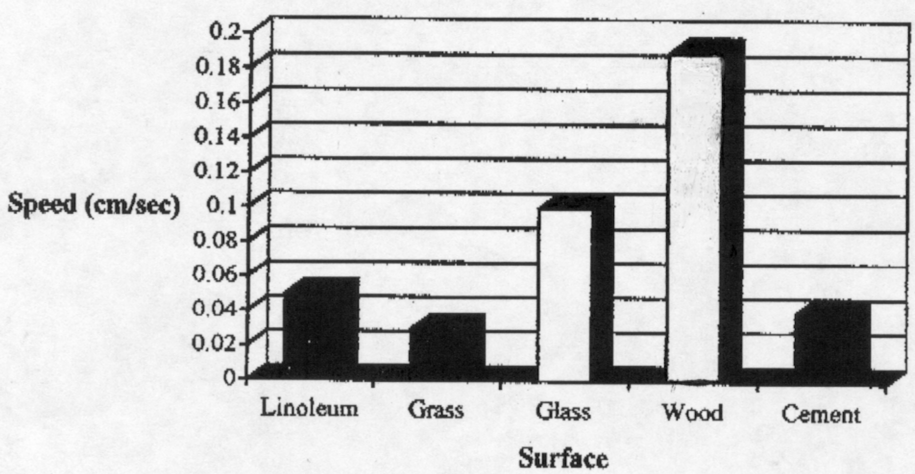
How Fast a Snail Can Travel

		Distance (cm)			Time (sec)	(cm/sec)
Surface	Trial 1	Trial 2	Trial 3	Average	Time	Speed
Linoleum	4.1	2	2.9	3	60	0.05
Grass	2.7	0	2	1.6	60	0.03
Glass	5	7.8	5.2	6	60	0.1
Wood	13	13.5	8	11.5	60	0.19
Cement	3	1.5	2.7	2.4	60	0.04

Observations:

On surfaces other than the wood, the snail did not move for a period of time, did not go in a straight line, or changed directions many times. When we placed the snail on the surface, the shell would be towards the back end of its body. Then it would move the shell up closer to the front of its body while it was moving. Also, sometimes when the snail was not moving, people would poke at it or yell at it to move, and the timing was sometimes off by a few seconds.

How Fast a Snail Travels on Different Surfaces



Analyzing and Interpreting Results

Results and Patterns:

We found that the snail travelbd the fastest on the wood at a speed of .19 centimeters per second **cps** It traveled .1 cps on glass, .05 cps on linoleum, .04 cps on cement, and .03 cps on grass. The pattern we found was that the smoother the surface, the faster the snail traveled, with the exception of the wood. Also that towards the end of the experimentation, the snail seemed to be moving slower and slower.

Conclusion and Explanations:

My hypothesis was somewhat correct. I thought that the snail would travel the fastest on the linoleum and glass, and the slowest on the grass, cement, and wood. In reality, the snail traveled the fastest on wood, glass, and linoleum and the slowest on grass and cement. I can conclude from these results that the snail moves the fastest on more smooth surfaces (as the wood was relatively smooth) because of the reduction of friction between the snail and the surface. Also that the snail travels slower on rough surfaces because there is more friction between the snail and the surface.

Review Your Design:

Some limitations in the design of the procedure was that we because we collected our data all at one time, the snail probably got more tired towards the end of the collection, and had more energy towards the beginning of the experiment. Also that we could not control which way the snail moved on the surfaces. Since we only had meter-sticks, we could not measure all the twists and turns the snail traveled in, just the vertical movement.

Factors that may be responsible for errors in the data are that if the snail was not moving or going the wrong way, people would poke at the snail and yell at it possibly agitating the snail. Also, since two of the surfaces were only found outside (cement and grass) we could not control the drastic change of temperature from inside to the cold conditions outside. Also, as mentioned before the snail changed directions many times, and we could only measure the vertical distance that the snail traveled. Some other factors could be that the spray bottle was working properly, so sometimes the snail didn't get wetted properly; the lettuce was very dried out and not very fresh towards the end of the experiment; and the timing of sixty seconds sometimes went over or under.

There are many improvements that could be made to the design. Instead of using meter-sticks, we could have used a tape measure to measure the slime trail of the snail, which would more accurately measure the horizontal and vertical movements of the snail. Also, if we could have controlled the temperature by doing the experiment on a day that it was about the same temperature outside as it was inside, it would have improved upon the results. If we could have waited a day or so inbetween each experiment, the snail perhaps wouldn't be as tired and would've performed with the same energy on each surface.

A question I might not want to investigate based on my conclusions would be "how does friction affect the speed a snail move?" Another question that I might not want to investigate would be "can a snail pull a certain mass faster on glass or cement?"

Water Filter
Materials Price Sheet

These are the materials you may use to build your water filters, and their costs:

filter holder	$1.00
wire screen	$1.00
1/4 cup gravel	$1.00
1/2 cup pebbles	$0.50
1/4 cup sand	$0.50
cheesecloth square	$0.50
cotton ball	$0.50
paper filter	$0.25

Name: ______________________ Date: ______________

Water Filter
Engineering Design Process: Ask!

Your goal for today is to **design a water filter that can make polluted water cleaner.** Your filter should be able to take large particles, small particles, sticky things, and some chemicals out of the polluted water sample.

In earlier lessons you have learned about water contamination and how filters work. Now is the chance for you to put that knowledge to work! What do you know that will help you to design a water filter?

Your water filter will be evaluated in these ways:

1. **Color Test Score:** How well it cleans the water.

2. **Cost Score:** How much it costs to build.

3. **Speed Score:** How quickly it can filter 1/2 cup of water.

Name: ______________________ Date: ____________

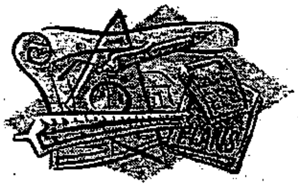
Water Filter
Engineering Design Process: Imagine!

What will you do to solve the problem? Brainstorm with your team. Draw pictures of your ideas below or list your ideas on the back of this sheet. Circle the idea you think will work best.

Water Filter
Engineering Design Process: Imagine!
(page 2)

List your water filter ideas.
Circle the idea you think will work best.

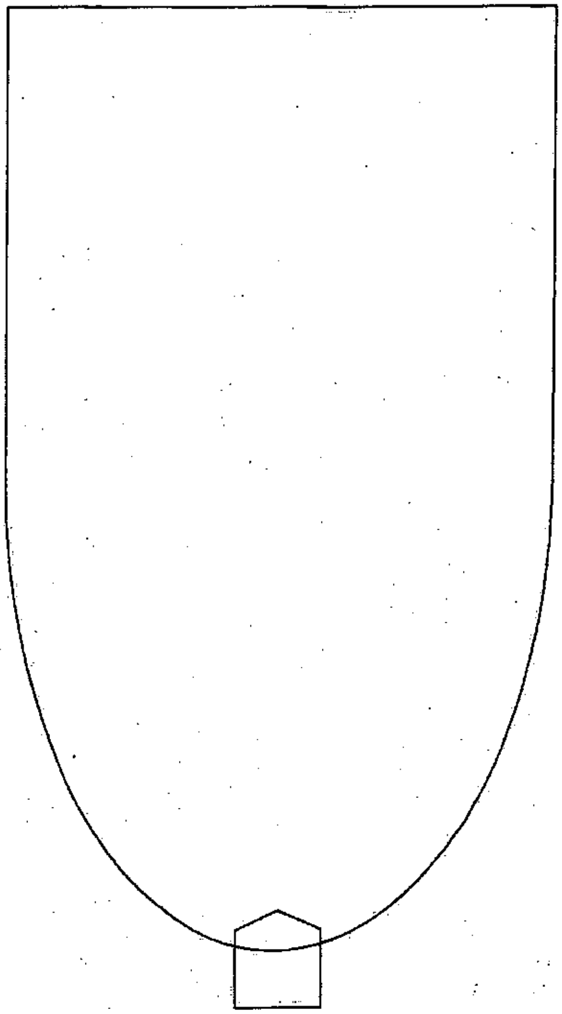
Name: ______________________ Date: ______________



Water Filter
Engineering Design Process: Plan!

Design #

Draw a diagram of your plan with labels.
List the materials you will need.
On the back, calculate how much your plan will cost to build.



Name: ______________________________ Date: ______________

Water Filter
Engineering Design Process: Create!

Design #

The total cost of our filter: ______________

Our filtered water most closely matched Formula # __________

Time to filter 1/2 cup of water: ________________

What happened to your filter when you tested it?

____

____

____

What part of your design worked best? What didn't work?

____

____

____

What can you change to make your design better?

____

____

____

Name: ______________________________ Date: ______________

Water Filter
Design Evaluation: Scoring Instructions

Color Test Score: Compare the filtered water sample from your design with the formulas. The number of the formula that looks the most like your filtered sample is your score.

Example: My filtered water sample looks most like Formula 3.
My Color Test Score = 3

Cost Score: Choose the score for the cost of your design.
Score of 1: $10 or more
Score of 2: between $8 and $10
Score of 3: between $6 and $8
Score of 4: between $4 and $6
Score of 5: less than $4

Speed Score: How quickly did your design filter 1/2 cup of water?
Score of 1: 2 minutes or more
Score of 2: between 1 and 2 minutes
Score of 3: less than 1 minute

	Design #:	**Design #:**	**Design #:**
Color Test Score			
Cost Score			
Speed Score			
Total Score			