Study Guide/ Practice Questions

In many courses students study for exams by memorizing the information presented during class. We suggest that you consider an alternate method to study for exams in this course. You will find that the skills that you have been developing are the more important than a body of information. Concentrate on the big ideas behind the questions, not necessarily the specific subject matter in the questions. The questions on the exams will be like the end of module questions and the end of class questions – they will require you to apply the skills you have learned in this class to different problems.

The following are some of the things you should know and be able to do for the exam:

1. What is the difference in an observation and an inference? You might be expected to identify observations and inferences from a scenario.

2. You should be able to construct a scatter-type graph and a histogram with the standards established in this class. You should be able to interpret the graph and decide if there is a relationship between the two variables that you have plotted. You should be able to use the graph to decide if two things are similar or different (e.g. are the pennies within one box similar in mass to the pennies in the other box?). You should also be able to identify problems with graphs if there is an error in plotting, labeling, or organizing a graph.

3. If given a situation, you should be able to discuss the scientific models presented. We will not expect you to critique the science, but you should be able to determine if data support or reject a model. You should also be able to determine if an idea or model is testable.

4. You should be able to determine how an object changes when one or more dimensions of the object is (are) changed (made smaller or larger by a factor). If the object is doubled (or halved or increased in all dimensions by a factor of 1.3), how has the object changed in perimeter, length, area, and volume of the object changed? You should be able to answer these kinds of questions without using a formula to calculate the changes. (after all, we don’t know the formula for a baby elephant or a millipede).

5. You should be able to make unit conversions (we will supply the identities for you).

6. You should be able to determine the height of the rain if given the volume of water collected and the area of the rain gauge. You should also be able to determine the volume of water collected if you have the height of the water and the area of the opening in the rain gauge. And so forth……

7. You should be able to apply these basic principles to other situations. For example, what volume of soil is needed to cover an area if we want a certain depth of soil? The principles are the same as the rain gauge problems.
Practice Questions:

The purpose of these study questions is to give you practice answering questions that are similar in style to the questions that might be on the exam. I make no promises that if you know the answers to these questions that you will be able to do the ones on the exam! However, practice is important to develop the skills needed to solve the problems that will appear on the exam.

Attempt the questions prior to coming to class on October 21. We will spend part of the day in groups working on the questions. If you have attempted to solve the questions and have answers to the questions, you will be assigned to a group. If you have not worked on the questions, you will work with other students who have not completed the questions.

1. A very ‘wet’ cloud dumped ‘buckets’ of rain onto your collection of containers (A, B, C, and D). Two centimeters of rain fell throughout the duration of this storm.

   a) Would the height of rainwater in each container be the same? _________ Explain your logic.
   Yes. The height of the water would be 2 cm in each container because they all have straight sides.

   b) Would the amount (volume) of water in each container be the same?  __________ Explain your logic.
   No. Although the height of the water in each container is the same, the areas at the top are different, so the containers will hold different volumes of water.

   c) Calculate the volume of rainwater found in each container.

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Volume</td>
<td>25.12 cubic cm</td>
<td>60 cubic cm</td>
<td>14.13 cubic cm</td>
<td>100.48 cubic cm</td>
</tr>
</tbody>
</table>

   d) What property of a container determines how much (volume) rainwater will be collected? __________
   The area of the opening at the top of the container.
e) What property of a container determines the height of rainwater in the container? 

*The shape and size of the bottom of the container.*

f) If the heights of the columns of rainwater in a collection of containers are the same, what is the relationship between volume of rain in each container and the area of each container?

*We know that the container must have straight sides and that the volume of water collected depends on the area of either the top or bottom of the container. (This only holds for straight sided containers.)*

g) Another rain gauge was used to collect rain in the same storm. If the tube at the bottom of the gauge is only two inches in diameter and one-ninth the area of the top of the gauge, determine:

The volume of the water in the tube ____________

*We know from the start of the problem that it rained 2 cm. If the area at the top of the rain gauge is 9 times greater in area than the base area, the height of the water in the tube must be 9 times greater than the height on a ruler. Therefore the height of the water in the tube must be 2 cm X 9 = 18 cm. The volume of water in the tube at the bottom would be the area of the tube (3.14 r^2) time the height of the water = 364.6 cubic cm.*

(Hint: Remember the area is one ninth of the area of the top).

Height (as measured with a ruler) of the water in the gauge:

e) Discuss why rain gauges are designed with a greater cross-sectional area at the top compared to the cross-sectional area at the base.

*If the area at the top of the gauge is greater than the area of the tube at the bottom, it is easier to read small amounts of rain. For example, a 0.1 inch rainfall would be very difficult to distinguish from 0.05 or 0.2 inches in a straight sided can, but most rain gauges make this easier to determine.*

f) What are the most reasonable units for measuring rainfall?

*Since the shape and size of each rain gauge is different, it is best to measure rain in inches or centimeters rather than in volumes.*

2. Observation/Inference

A student is given a sealed box with an unknown item or items contained inside. (Sound familiar?) The student is asked to try to characterize the object(s) in the box by shaking and moving the box. The following is what the student recorded:

Makes a tinny sound when shaken.
Feels heavy
rolls on one side, slides on the other
sounds like metal
only one object in the box
object is small
shape is a tube or cylinder

a. Which items on the list are observations about the object(s) in the box? Explain.
   *Makes a tinny sound when shaken.*
   *Feels heavy*
   *rolls on one side, slides on the other*
   *sounds like metal*

b. Which are inferences? Explain.
   *only one object in the box*
   *shape is a tube or cylinder*
   *object is small*

c. Which do you think are overly vague or non-specific?
   *Makes a tinny sound when shaken.*
   *Feels heavy*
   *object is small*

3. A model is scientific if it can be tested by experiments. For each of the following three models, state whether you think the model can be tested and then give an example of a test that could be done or explain why no test is possible.
   a. As trees grow, the trunks of trees get new tree “rings” every year.
      i. Can this model be tested? *Yes it can be tested*
      ii. Describe a possible test or explain your reasoning.
         *We could bore into a tree and count the rings and do the same thing one year later and we should have an additional ring in the second observation.*
   b. The trees that grow fastest are the trees that want to grow fastest.
      i. Can this model be tested? *No, it cannot be tested.*
      ii. Describe a possible test or explain your reasoning.
         *There is no way to determine if a tree wants to do something since we can’t reliably communicate with trees.*

4. a) Student Bob tells student Keith, that the wood in a tree comes from the tree absorbing water and nutrients from the soil. (*This question is about models, not plants*).

Is Bob’s model a scientifically testable model of plant growth?

*This is a testable model. We could determine if the soils have the necessary materials for the photosynthesis process. We could also see if trees will grow in just water, with*
no soil. (This is not a long term experiment because the tree is not structurally stable in just water.) – It turns out that trees absorb the carbon dioxide they need for photosynthesis through their leaves and needles—the mass of the tree does not come from the soil!

b) The current hypothesis for the demise of the dinosaurs was the impact of a comet or meteor which created a catastrophic series of ecological events that lead to the extinction of dinosaurs.

An alternative suggestion for the extinction of the dinosaurs prior to the impact hypothesis was that dinosaurs died away at about the same time that angiosperms (flowering plants) evolve and that dinosaurs eat too many of these plants and died of stomach aches (really! 😊). Is this idea a useful scientific idea? Why/Why not?

One cannot test whether the dinosaurs died of a belly ache, so this is not a useful scientific idea. There is no way to determine if we find the fossils of a dinosaur if it had a stomach ache when it died.

5. Imagine that you work for the National Science Foundation and it is your job to evaluate research proposals for funding. Answer the questions below for the proposed plan below:

The purpose of this proposed study is to see if putting fertilizer around trees would decrease global warming. Carbon dioxide is one of the primary “greenhouse” gases in the atmosphere. Higher air temperatures are thought to happen when there are increases in the level of carbon dioxide in the atmosphere. Increases in carbon dioxide are due to emissions from all types of combustion including cars, buses, burning of coal and natural gas as well as several other sources. Naturally vegetation removes carbon dioxide from the atmosphere in the photosynthesis process. Our proposal is to evaluate whether increased tree growth due to the application of fertilizer in parts of the Snoqualmie National forest (near Snoqualmie Pass) will decrease the level of carbon dioxide in the atmosphere, thereby decreasing the effect of the greenhouse effect compared to a similar stand of trees that will not be fertilized in the Mt. Baker National Forest near Bellingham.

What is the dependent variable in this experiment?
The dependent variable is the one we measure. In this experiment, the amount of carbon dioxide in the atmosphere would be the dependent variable.

What is the independent variable in this experiment?
The independent variable is the presumed cause of the variation in the dependent variable. In this experiment it is the amount of fertilizer put around the trees.

If funded will the results of the study be applicable to other areas of the world?

6. Weather and climate phenomena are often too large to measure directly so scientists resort to measuring a sample and assuming that the rest of the sample is similar (this is an example of extrapolation). During the first minute of a rain shower, Ajay noticed that 30
raindrops fell in a one-foot by one-foot section of his deck. During that same minute, how many raindrops would you estimate fell on his entire 20-foot by 20-foot deck? (Show your work AND explain your reasoning.)

*If there are 30 raindrops in a 1 square foot area then there should be 30 X 20 feet = 12,000 drops on his deck.*

*Another way to solve this problem is to determine that the deck is a factor of 20 greater in both directions than the 1 foot area given in the problem. If we square 20= 400, so the deck is 400 times greater area than the 1 ft x 1 ft area given. We multiply 30 raindrops times the area and we have the same answer.*

7. The following two graphs show two different ways of representing the data for average temperature as a function of year. Which method is preferred and why?
Both graphs have their purposes. Most of the time in this class we will be using scatter graphs and a trendline so that we can determine the equation of the line to be able to interpolate (estimate values between points on the graph) or extrapolate (extend the result of the experiment beyond the limits of the data collection). Since our goal is an average temperature graph, the trendline in the first graph helps us determine the overall average better.

The second graph is sometimes called a time-series graph. If we want to trace the progress of temperature change or your children’s height or the Dow Jones Average or… a time-series graph is sometimes helpful.

8. The Earth’s atmosphere was once much warmer and contained more oxygen than it does today. As a result many of the organisms that thrived then cannot survive under modern conditions. 280 million years ago there were two families of dragonfly. One had a wingspan of about 5 centimeters (2 inches), and was thus the same size and shape as the dragonflies of today. Another, called Meganeuria, was much larger with a wingspan of 75 centimeters (30 inches), but was the same shape with the same proportions as today’s dragonfly (that is to say Meganeuria was longer, thicker, and wider than today’s dragonfly).

a) How did the surface area of Meganeuria compare with the surface area of dragonflies today? (Be quantitative and explain your answer.)

Before we go into the solution, consider what we saw in class and in the homework. We looked at spheres, cubes, tetrahedrons, baby elephants, and millipedes. In each case we saw that if

Length increases by a factor of 2,
then Area increases by a factor of $2^2$ or 4,
and Volume increases by a factor of $2^3$ or 8,
If Length increases by a factor of 3, then Area increases by a factor of $3^2$ or 9, and Volume increases by a factor of $3^3$ or 27, And so on.

a) How did the surface area of *Meganeuria* compare with the surface area of dragonflies today? (Be quantitative and explain your answer.)

The wingspan of *Meganeuria* is greater than the wingspan of a modern dragonfly by a factor of:

\[
\frac{75\text{cm}}{5\text{cm}} = 15
\]

Notice that this says *Meganeuria* was "fifteen times larger" and not "fifteen centimeters larger"

Since wingspan is measured in units of Length, we can conclude that:

*Length increases by a factor of 15,*
*then Area increases by a factor of $15^2$ or 225,*
*and Volume increases by a factor of $15^3$ or 3375.*

The surface area of *Meganeuria* was 225 times larger than the surface area of dragonflies today!

b) How did the volume of *Meganeuria* compare with the volume of dragonflies today? (Be quantitative and explain your answer.)

By the same logic…

The volume of *Meganeuria* was 3375 times larger than the volume of dragonflies today!!!
(0.5 inches) × \( \text{area}_{\text{top}} \) = (actual height) × \( \text{area}_{\text{base}} \)

(0.5 inches) × \( (\text{some#})(3.5 \text{ in})^2 \) = (actual) × \( (\text{some#})(1.7 \text{ in})^2 \)

(actual height) = \( (0.5 \text{ in}) \times \left( \frac{(\text{some#})(3.5 \text{ in})^2}{(\text{some#})(1.7 \text{ in})^2} \right) = (0.5 \text{ in}) \times \left( \frac{3.5 \text{ in}}{1.7 \text{ in}} \right) = 2.1 \text{ in.} \)

So the 0.5 inch mark should be 2.1 inches above the bottom.

b. Assume you had a rain gauge in Aurora that was capable of collecting all the rain on that day. The top of the rain gauge has a diameter of 3.5 inches and the base of the rain gauge has a diameter of 1.7 inches. If the rain gauge was able to collect all of that rain without overflowing, how tall would it have to be?

2. Same logic:

(17 inches) × \( \text{area}_{\text{top}} \) = (actual height) × \( \text{area}_{\text{base}} \)

(17 inches) × \( (\text{some#})(3.5 \text{ in})^2 \) = (actual) × \( (\text{some#})(1.7 \text{ in})^2 \)

(actual height) = \( (17 \text{ in}) \times \left( \frac{(\text{some#})(3.5 \text{ in})^2}{(\text{some#})(1.7 \text{ in})^2} \right) = (17 \text{ in}) \times \left( \frac{3.5 \text{ in}}{1.7 \text{ in}} \right) = 72 \text{ in.} \)

Which is six feet tall. Good rain gauges come with mechanisms to collect overflow so that they won’t have to be six feet tall.

c. Buildings and roads have a big influence on drainage because they are waterproof. Imagine a developed segment of Aurora, Illinois, where 80% of the land is either paved or covered with a building. The remaining land is covered with lawn and shrubs. If nothing special was done to handle the drainage from the roads and buildings (in other words, no storm drains and no gutters leading to special drainage areas) how many inches of rain would the grass-covered land have to absorb?

Here we are told that however great the volume of water that fell in this area, it had to be absorbed into only 20% of the surface area. If you think of a container of water that you then pour into a container with only 20% (or one-fifth) of the horizontal area, the column of water in the new container will be five times as tall. So the grassy areas (the only areas that are porous) would have to absorb the equivalent of 5 x 17 inches = 85 inches or seven feet! This is worse than the rain gauge. If you try to imagine a patch of lawn trying to absorb a pool of water seven feet deep you get the idea of why gutters and good storm drains are so important.
10. Joey is building a new gravel road around the edge of his ranch. The whole road will be a quarter of a mile long and 15 feet wide. He has to spread the gravel to a depth of 2 inches.

a. How many cubic yards of gravel does he need?

Unit conversions… We need to figure out volume which is length times width times height but the length is in miles, the width is in feet and the depth is in inches. We want the whole thing in yards. You can do this all at once or one piece at a time. This is the one piece at a time approach:

\[
(0.25 \text{ mile}) \left( \frac{1760 \text{ yards}}{\text{mile}} \right) = 440 \text{ yards}
\]

\[
(15 \text{ feet}) \left( \frac{1 \text{ yard}}{3 \text{ feet}} \right) = 5 \text{ yards}
\]

\[
(2 \text{ inches}) \left( \frac{1 \text{ yard}}{36 \text{ inches}} \right) = 0.0556 \text{ yards}
\]

Volume = \( (440 \text{ yd})(5 \text{ yd})(0.0556 \text{ yd}) = 122.2 \text{ cubic yards} \)

b. Since gravel is good for drainage, the city will allow him to get a permit to build a new barn if the gravel covers an area greater than half of an acre. Is the road big enough to get him the permit?

One acre is 4840 square yards. The area of his road will be

\[
(5 \text{ yd})(440 \text{ yd}) \left( \frac{1 \text{ acre}}{4840 \text{ sq.yd}} \right) = 0.455 \text{ acres}
\]

Nope, that’s not quite half of an acre but he would only have to add a small drainage area (0.045 acres) to get his permit. If he lengthens his gravel road by 44 yards he’ll be fine.