

Some Fundamentals of Math and Science

Pre-Lab assignment:

- Start your personal "journal"**. Refer below to parts **5 (a) and (d)** of the procedure.
- Giving yourself one hour to do so, complete in your journal as much of each of the ten activities given in this write-up as you can.** (Your may expend more than one hour on this if you like, but we consider one hour of your brain's time as a good-faith effort.)
- When you come to lab, bring your "journal"**.

Format of the Activities

- At the end of today's period, each student will take a **quiz** related to today's lab.
- You and other students will **form groups** to perform this experiment collectively. Each group should submit a series of group reports on the various activities in this lab.
- After your group has made sufficient progress on an activity (as judged by your instructor), your group will have access to a **model report** for that activity.
- The scoring system** used rewards students who can demonstrate understanding while also helping others to do likewise, and groups in which all members fully understand reports submitted by the group. The details are given below.

Procedure:

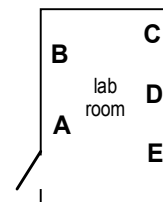
1. Key Aspects of today's activities. Read the "Format of the Activities" section above.

2. Form your Group.

- Join with other students to form a group of 4 students. Choose a lab table for your group, and sit around that table.

(**Note to instructors:** All groups should have either 3 or 4 students. There should be as many groups with 4 students each as possible. Depending upon how many students there are in the class, there may be from 0 to 3 groups which have only 3 students each.)

- Determine a letter or name for your group, using a letter (or a name that starts with that letter) determined as follows: the group nearest the lab door should use A. Other groups use B, C, etc., in order, going clockwise around the lab room.
- Choose an unique number to identify yourself within your group, using from 1 to 4 if your group has four members.



3. Strategies for maximizing your points.

Discuss briefly with others in the class strategies for maximizing points as an individual, as a group, and as a class.

Points will be awarded using one or more of the following factors:

- Quiz points:** There is a quiz at the end of the period; each student receives points for each question he/she answers correctly, as does each member of that student's group.
- Group report points:** Each member of a group receives points for a satisfactory report submitted by the group. Excellent reports will receive the most points; less than excellent reports may be returned with comments, so that the group has a chance to resubmit an improved report (to recoup part of the points they failed to earn).
- Section points:** Each lab section receives points which reflect the performance of the section as a whole. Hence, consultation between groups is both permissible and encouraged.

- d. **Journal points:** During the period, each student's lab journal (discussed below) may be checked for quality; some points will be awarded on that basis.

Your instructor will decide **after** your lab class which of these factors to use for a given section.

4. The Activities.

Scan briefly the following parts of this write-up, to see what they are about.

- The "**Summary Report Sheet**", which lists the activities;
- The lab activities and accompanying information.

5. Start Doing the Lab Activities!

- Your personal journal:** Each of you is expected to keep a "journal" or record of **your** thoughts and efforts on each activity, made while working either alone or with others. Several sheets of paper stapled together can serve as a "journal". **Your journal should have a heading such as shown below, and the pages should be numbered.**

Example Heading on a Personal Journal

<i>Journal of A2 - Cy Cyclone</i>	4/1/2000	<i>sect. B, Phys 111, Exp. M3</i>
-----------------------------------	----------	-----------------------------------

- Assign roles to each person in your group as outlined in the table below.

Person	Role	Duties
#1	Manager	Keeps things moving, makes sure others do their job, submits reports for the group
#2	Recorder	Writes the group's reports (see below)
#3 & #4	Checker/ skeptics	Checks the group's reports before submission; plays "devil's advocate", looking for reasons why work in the report may be wrong; critiques the quality of the work (Is the work of professional quality?).

(Of course, when you solve problems by yourself, you should be the manager, recorder, checker and skeptic, all in one! These are the major functions that professionals in technical fields exhibit when they solve problems. When developing your problem solving skills in a group setting, it can be helpful to identify and separate these functions, as we are doing today.)

- Start working on the first activity! Each of you should work a bit in your journal.** Help each other as you see fit.
- Some Reminders:** As with all records of scientific work, **such as your journal and your group's reports**, you are expected to:
 - **Use non-erasable pen** (except perhaps when making graphs or sketches);
 - **Preserve any original data records**, and submit them with reports based on that data;
 - **Show all your calculations!** Those who must rely on your work should not have to repeat your calculations to confirm or discover what you did.
 - **Follow the professional practices enumerated in the Introduction to the lab manual.**
- The group should do the lab activities **in order** (1, 2, etc.)
- The recorder's responsibilities and related comments:**
 - **The recorder should write a group report for each activity.**
 - The recorder should **use a separate sheet(s) for the report for each activity**, using paper of your group's choosing.
 - The recorder should write a **heading on each group report (see the example below)**.

- The recorder's personal journal will be considerably less extensive than that of the other students, since the recorder will work much of the time on the group's report.

Example of Heading for Each Group Report

Group: Aardvarks Sect. B 4/1/2000

Recorder: A2 - Cy Cyclone

Activity #6 - Define the term, "percent".

(Leave space here for the checker's signature(s) and remarks)

/

g. **The Manager** for your group has a number of specific responsibilities.

- The manager is responsible for the Summary Report Sheet included in this write-up. The manager should complete the heading on this sheet (as illustrated below) and attach the sheet to the group's folder. **This folder should be kept at the end of your group's lab table.**

Group: Aardvarks Lab Section: B Day, date, lab time: Thursday, 4/1/2000, 10 AM

Give the letter & # (e.g., A3) and name for all persons listed below.

Manager: A1 - Ike Newton

Recorder: A2 - Cy Cyclone

Problem Checker/Skeptic(s): A3 - Jimmy Joule; A4 - Heiny Hertz;

- As the report for each activity is finished, the manager should put the report **in your group's folder** and **update the summary sheet attached to the folder.**
- The manager should submit the report for each activity to the group's folder **before the group gets much involved in the next activity.** Half finished reports should not pile up at your group's table.
- **Before leaving class, the manager** should double-check that the summary sheet (attached to the group's folder) is accurate and up-to-date, and that the checks listed at the bottom of the sheet have been completed.

h. **The Checker/skeptic** also has a number of specific responsibilities.

- The checker/skeptic should review each activity report before it is submitted by the manager. In particular,
 1. Does the report address the problems raised and the question(s) that were asked in the activity?
 2. Are the results reasonable? (For example, if a result is numerical, does it have a reasonable magnitude, or is it far too large or too small?)
 3. Is the mathematics and/or the logic in the report correct?
 4. Is the report complete, with all appropriate steps shown?
 5. Do calculations and results in the report include all appropriate (and correct!) units?
 6. Is the report of professional quality? (Refer to the checklist on page 8 of the Introduction to the lab manual.)

If some of the work appears to be incorrect or in need of redoing, the checker/skeptic should discuss the matter with the group. If the group agrees with the checker/skeptic, the **recorder** should draw a line through the questionable work, make a notation of the problem or concern, and then redo that work.

7. After any necessary corrections or improvements, the checker should write on the report (immediately below the heading), "Checked by (checker's signature)". The checker may add any appropriate additional remarks of his/her choosing such as, "this report should be neater", or "I still do not know why the forces in part b do not add exactly to zero", or whatever.
 - After your instructor gives your group permission to inspect the model report for a given activity, the checker/skeptic (and any other group members who would like) should review the model report, and report to the group any discrepancies or apparent weaknesses in the group's report. After the group discusses the matter, **the recorder** should write any improvements or comments on the group's report after the phrase, "**Additions made after the review of the model report:**".
6. **Continue Performing the Lab Activities.**
 - a. Your group should continue the lab activities, as time permits.
 - b. If your instructor judges a report to be unsatisfactory, or in need of improvement, he/she may return it to you for further work (and additional credit).
 - c. Your instructor will inform your group when you are permitted to inspect **the model report** for a given activity.
 - d. **If your group has serious problems functioning well**, reassign roles within the group. Your group should also discuss briefly any changes that might improve the functioning of your group. If all else fails, discuss the matter with your instructor.
7. After finishing the quiz, **each student should place their completed quiz sheet in the Group's folder (on top of the reports and journals).**

Good Luck on the Quiz!

Summary Report Sheet

Throughout the class, an accurate and up-to-date copy of this report should be attached to your group's folder located at your group's table.

(This is a responsibility of your group's manager.)

Group: _____ Lab Section: _____ Day, date, and lab time: _____
Give the letter & # (e.g., A3) and name for all persons listed below.
Manager: _____ Recorder: _____
Problem Checker/Skeptic(s): _____; _____;

Report submitted?	Instructor's marks and/or remarks	Permission to inspect Model Report?	#	Activity Type	Description of Activity
			1	Trig. #1	Determine the size of an angle (drawn on a sheet of plastic), using only a sheet of graph paper and your calculator. (Protractors are not allowed!)
			2	Geometry #1	Measure pi: Using a bicycle and a meter stick, determine a value for pi.
			3	Geometry #2	The volume of a sphere: Choose the correct formula from a list, and give a convincing argument for the choice.
			4	Geometry #3	How many 1 cm cubes fit into a single 1 m cube?
			5	Math Terms #1	What does the term, "directly proportional", mean? Define it in three forms: words, an equation, and a graph.
			6	Math Terms #2	Define the term, "percent".
			7	Eqn. Check #1	Does $(a+b)^{1/2} = a^{1/2} + b^{1/2}$? Is this equation valid? Give a convincing argument for your answer.
			8	Fractions #1	Find the sum of $1/3 + 1/2$. Demonstrate the validity of your result with physical objects.
			9	Puzzle #1	Determine the height of an unseen alien in earth units. You have met one alien, but not the one of interest.
			10	Puzzle #2	Consider two cylindrical tanks; initially one is full and one is empty. Water then flows through a tube connecting the tanks. Describe the principle(s) that can be used to determine the final water level in the tanks.

Manager's Check-Lists:

- All sheets (if there is more than one sheet) of each group report are stapled together: _____.
- Order of materials: Reports are in reverse numerical order (last done on top) _____;

End of period checks:

- This folder contains quizzes (on top), reports (in reverse numerical order), and journals (following other materials in the folder). _____
- Each journal **has a proper heading** and is stapled (or bound) and enclosed: _____

#1 - Trig #1: Determine the size of an angle without using a protractor.

Using **only** a piece of graph paper and a scientific calculator (and not a protractor!), is it possible to accurately determine (the size of) an angle drawn on a sheet of transparent plastic? If so, describe how to do so. If not, explain why that is the case.

If you believe it is possible to determine the angle:

1. determine the angle drawn on the transparency provided;
2. then measure the angle directly with a protractor;
3. then compare the values for the angle (determined by these two different methods). How well do they agree?

#2 - Geometry #1: Measure pi.

Your group is stranded on a planet with a meter stick and a bicycle, but no books or calculators.

1. Describe a method for determining π under the conditions described.
2. Determine an experimental value for π , giving a rough estimate of the uncertainty in your result. Use the bicycle or any other appropriate object that is available.

#3 - Geometry #2: The volume of a sphere of radius, r, and density, d.

You have written a number of mathematical expressions in your notes, namely:

$$2\pi r; \quad \pi r^2; \quad 4\pi r^2; \quad \left(\frac{4}{3}\right)\pi r^3; \quad \pi d^3$$

You know one of these represents the volume of a sphere, but you can't remember which one. Which of these is the correct expression, and construct an argument stating why your choice is the only one that can possibly be correct.

#4 - Geometry #3: How many cubes in a cube?

Consider a meter stick. Now consider constructing a cardboard box in the shape of a cube, with dimensions of 1m x 1m x 1m.

Now consider a small cube, 1 cm x 1 cm x 1 cm, about the size of common dice (such as are available in lab).

Determine how many of these small cubes (or dice) can be shipped in the cardboard box. Construct an argument (in words) that would convince someone who is not mathematically sophisticated of the validity of your result.

#5 - Math terminology #1: What is meant by the term, "directly proportional"?

You are stranded on a planet without books or calculators; in particular there are no math books.

The first book to be published on this planet is a math book. The publisher of the math book asks you for a definition of the term "directly proportional", as in the sentence, "The distance traveled when running at constant speed is directly proportional to the time elapsed."

State the definition of "directly proportional" in three forms, namely, in words, as an equation, and as a graph.

#6 - Math terminology #2: What is meant by the term, "percent"?

The percent mystery: You are stranded on a planet without books. You and your fellow travelers remember that much use was made of the term "percent" back on earth. For example, sales tax was 6 percent (or 6 %), marginal income tax for some was 33%, and interest rates paid by banks were about 5%.

It is your task to write an understandable definition for the term "percent".

#7 - Equation checking #1: Does $(a + b)^{1/2} = a^{1/2} + b^{1/2}$?

You are stranded on a planet without books or calculators; in particular there are no math books.

The first book to be published on this planet is a math book, and you are asked to review it (for accuracy). The publisher asks if the following equation found in the book is valid or not.

$$(a + b)^{1/2} = a^{1/2} + b^{1/2}$$

Is this equation valid or not? What is your opinion, and give your best argument for your position.

#8 - Fractions #1: Find the sum of $1/3 + 1/2$, and demonstrate its validity.

Consider the sum: $1/3 + 1/2$

Determine this sum. Then describe in words a demonstration, using materials available in the room, that demonstrates with physical objects the validity of your result. Your demonstration should be convincing to someone who is not mathematically sophisticated.

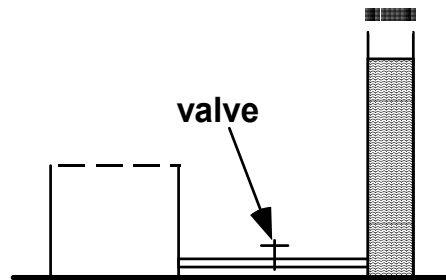
#9 - Puzzle #1: Determine the height of an unseen alien in earth units.

You are talking to an alien, Al, by phone. You know that Al is 30 inches tall (Al was measured when he recently visited earth.), but Al's brother Bill has never been to earth. The brothers currently are located in the galaxy Zircon and do not have a tape measure. However, Al measures himself and Bill using (alien) coins. From this you learn that Al is 50 coins tall and that Bill is 75 coins tall.

Can you determine Bill's height (in inches) from this information? Give a detailed convincing argument for your answer, giving as much detail as you can.

#10 - Puzzle #2: Two connected cylinders of water

A tall, narrow cylindrical tank (of radius r_1) is filled to a height, h_1 , with water. A second cylindrical tank which is shorter and considerably wider (radius r_2) is initially empty. These two tanks are resting on level ground, and are connected near their bottoms by a narrow tube; the valve in this tube is initially closed, preventing flow of water from one tank to the other.



Consider the water level in each tank **long after the valve is opened**, and describe the principle(s), if any, that can be used to determine these water levels.

P.S. There may be a model of these tanks available in the lab.