Math Review for Physiology Students

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A) Understanding Range

If a set of numerical readings are taken by a scientist or clinician, it is likely that not all of the readings will be identical. For example, a person's cholesterol level will tend to vary according to the time of the day or depending on what foods have been recently consumed. One isolated measurement may not be enough to figure out the individual's typical, day-to-day serum cholesterol level. Some measurements will be higher than others. Thus, often, several measurements of the same thing are more revealing than a single one. However, in the end you will want to give a single measurement that is representative of all the others. This can be the **range,** and the **average** or **mean**.

If all the values are arranged in numerical order, from lowest to highest or vice versa, the **range** of values is the highest and lowest values in the series. For example, suppose that cholesterol readings over several days are 120 mg/100mL, 205 mg/100mL, 176 mg/100mL, 147 mg/100mL, and 234 mg/100mL. The lowest value is 120, the highest is 234. We can say the patient's cholesterol ranged between 120 - 234 mg/100mL.

1) Suppose that over a particularly rainy winter week the rainfall amount was measured at 2.5 cm on Sunday, 3.53 cm on Monday, 1.51 cm on Wednesday, 0.75 cm on Thursday, and 2.12 cm on Saturday. State the range of rainfall which fell during this week: ________________

2) Suppose that a person interested in his daily urine production measured his urine over a five-day period at 1,940 mL, 796 mL, 2,121 mL, 2,051 mL and 1,996 mL; all on different days. State the range of urine volume over the course of the study: ________

B) Understanding Average and Mean

Another way to express data is to calculate the average. The **average** is found by adding the values together and dividing by the total number of values. In the serum cholesterol example given above the sum of the measurements equals 882 mg/100mL. The total number of measurements taken was 5. Therefore, the average is 882÷5, or 176.4 mg/100mL. Another name for the average is the arithmetic mean, or simply the **mean**.

1) Calculate the average, or mean, of the rainfall per day during the week described above.
____

2) What is the average or mean amount of urine produced per day in the example on page 1?
___________________mL

3) Apparently it did not rain on Tuesday and Friday, so the rainfall for those days was 0 cm. If these days were included in the average, would it increase or decrease the result? If you did include them, your result shows the average daily rain. If you didn't include them, your result shows the average rain *when it rains*. The two averages have slightly different meanings. The lesson here is that it is important to be clear on what exactly an average is means.

4) Suppose you need to calculate how much urine an outpatient's kidneys produce each day. You tell the patient to measure his urine production over a week's time. He took measurements every day, but was traveling on one of the days and therefore unable to measure his urine that day. Would it be accurate to add 0 mL into the total and divide by 7? Why or why not?

5) Go back and look at the urine volume values given on the previous page. Notice that one day's measurement of urine is considerably lower than that of the other days, and therefore it lowered the average considerably. You might be justified in leaving that measurement out of your calculation if you knew it was due to extremely abnormal circumstances (i.e. the patient spilled the urine sample or didn't drink any liquids that day) but otherwise you should include it.

C) Understanding Percent

Mathematically, percent (which is often written using the symbol **%**) is always one number divided by another number times 100. This is shown in the box below, where the Special group is the number of things that have a special trait, and the General group is the total number of things, whether they have the special trait or not.

$$\frac{\text{Special group}}{\text{General group}} * 100 = \text{Percent}$$

For example, if the Special group is 2 and the General is 4, then the percent is 2 divided by 4 times 100. This is 50%. We say "2 is 50% of 4." Another example: If the Special group is 38 and the General group is 40, the percent is 38 divided by 40 times 100. This is 95%. We say "38 is 95% of 40."

Do both of the above percents on your calculator to confirm that you understand the procedure.

1) If the Special group is 7 and the General group is 11, the Special group is ______ % of the General group.

1) If the Special group is 233 and the General group is 312, the Special group is ______ % of the General group.

Calculating Percent from Data

In real-life physiology percent problems, you will not be told "Special group is this number and General group is that number. Calculate the percent." Instead, you must inspect the data given in the problem and figure out for yourself which number is the Special group and which is the General group.

An example of a real-life physiology percent problem is: "If 20 out of the 80 students in the class have not eaten breakfast, what % of students have not eaten breakfast?" How do you decide which number is the Special group and which number is the General group? The General group is always the number of the **entire group** being considered. The special group is always the number of things that have a special trait (the group *within* the larger group). Thus, General group is the entire class (80) and the special group isd the group within that group (the 20 who skipped breakfast). Doing the calculation, 20 divided by 80 times 100 is 25%. We say "25% of the students have not eaten breakfast."

3) Suppose that the class is made up of 40 students, and two of them have not yet bought their textbook. What % of them has not bought their book? ______________%

4) A woman gives 21 daily urine samples to her doctor for analysis. 3 of the samples had glucose in the urine (a symptom of diabetes). What % of her urine samples had glucose?

____

Sometimes the problem gives you the percent and **one** of the numbers (The special group number **or** the entire group number). You are then asked to calculate the other group number. For example, suppose that 5% of the students in the class have not yet bought their textbook. If there are 80 students in the class, how many have not yet bought their book?

To begin this type of problem, start by figuring out if the number that you were given is the special group or the entire group. Since 80 students is the entire class, they must be the entire group (the students who have not yet bought their book are the special group within the entire group). So the problem gave you the percent number (5) and the general group number (80). Next, use the % equation below to solve for the missing group.

Special group --------------- General group	* 100 = Percent

(You will have to rearrange the equation to solve for the missing group. If you are not sure how to rearrange equations, ask your instructor).

5) In one year, 120 individuals were diagnosed with AIDS in a particular city. Three years later, 15% had died. How many patients had died? ______ patients.

In most percent problems, the special group number is smaller that the entire group number. However, it is possible to encounter a situation where the special number is larger than the entire number. This is possible when one person (or one measurement) is being compared to an average or normal value. In that case, the normal value is considered the entire group and the one person (or measurement) is considered the special group.

For example, the normal annual rainfall for a particular year is 28 cm, but in a certain year the region gets 34.4 cm. Once again the rule to follow is to divide the special number by the entire and multiply by 100. In the above example the entire number is the normal 28 cm and the special number being studied is the 34.4 cm in that particular year. Doing the calculation 34.4 ÷ 28 x 100 = 122. The rainfall in that year, then was 123% of normal.

6) A patient's blood cell count shows 15,000 white blood cells (WBCs) per μL of blood. A normal WBC count is about 9,000 cells/μL What percent of normal is this particular patent's WBC count?

____

7) Obesity is defined medically as 20% above a person's ideal weight. If a person's ideal weight is 72 kg, when (above what weight) would that person be considered obese? ________________kg

8) If a man's ideal weight is 165 lbs. and he weighs 185 lbs., how many pounds above his ideal weight is he? What percent above his ideal weight is he?

______________lbs. above ideal weight

______________% above ideal weight

D) Powers of 10 and exponents

Numbers like 100, 1000, 10,000, 1,000,000 have a "1" and several zeros. These numbers are sometimes called "Powers of 10" numbers because each number is 10 times itself some number of times. For example, the number 100 equals 10 times itself 2 times: 100 = 10 x 10. And the number 1,000 equals 10 times itself 3 times: 1000 = 10 x 10 x 10. The number 1,000,000 equals 10 times itself 6 times: 1,000,000 = 10 x 10 x 10 x 10 x 10 x 10.

Mathematicians have developed a compact way to express powers of 10 numbers. They simply write 10 followed by a small number to show how many times the 10 is multiplied times itself. So:

100 $= 10^2$
1,000 $= 10^3$
1,000,000 $= 10^6$

The small number is called the exponent or the power. An easy way to figure out the exponent of a number is this: It is the number of zeros after the 1. For example, 100 has 2 zeros after the 1 so it is 10^2. The number 1,000,000 has six zeros after the 1 so it is 10^6

1) Write the following numbers as powers of 10.
   a) 10,000 = _______   b) 100,000 = ________   c) 10,000,000,000 = ________

2) Write the following powers of 10 as normal numbers:
   a) 10^7 = ________________   b) 10^1 = ________________

Numbers that are less than 1 can also powers of 10. For example, 0.01 is equal to 1 divided by 100 (1/100). You know from the above paragraphs that 100 is 10^2. To show 1 divided by 100 in exponents, mathematicians put a negative sign in front of the exponent:

$0.01 = 10^{-2}$

Another example is 0.001. This is equal to 1 divided by 1,000 (1/1000). You know that 1000 is 10^3. To show 1 divided by 1000 in exponents, mathematicians put a negative sign in from of the exponent:

$0.001 = 10^{-3}$

An easy way to figure out the exponent of a number less than 1 is this: It is the number of zeros to the left of the 1. For example, 0.01 has 2 zeros to the left of the 1 so it is 10^{-2}. The number 0.001 has 3 zeros to the left of the 1 so it is 10^{-3}.

3) Write the following numbers as powers of 10.
   a) 0.1 = _______
   b) 0.0001 = ________
   c) 0.000000001 = ________

4) Write the following powers of 10 as normal numbers:
   a) 10^{-6} = ________________
   b) 10^{-5} = ________________

The table below summarizes powers of 10 numbers and their exponents:

Number:	**Power of 10:**
100,000	10^5
10,000	10^4
1,000	10^3
100	10^2
10	10^1
1	10^0
0.1	10^{-1}
0.01	10^{-2}
0.001	10^{-3}
0.0001	10^{-4}
0.00001	10^{-5}

e) Scientific or Exponential Notation

Scientists often need to work with numbers that range from the very large to the very small. Such numbers are cumbersome to work with. For example, a bacteria cell might be 0.0000086 meters in length. It is much more convenient to write the same number in a more compact form called scientific notation:

$$8.6 \times 10^{-6}$$

The example above illustrates the key features of a number in scientific notation:

a) There is only one digit to the left of the decimal place. It can be any digit except zero.

b) The number is multiplied by some power of 10.

The steps below are how to convert any number into scientific notation. We will use the number 0.0000086 as an example.

a) Move the decimal point until there is only one non-zero digit to the left of the decimal point. You can ignore any zeros to the left of the new decimal point.

8.6

b) Write "x $10^{exponent}$" after the number. The exponent is how many places you moved the decimal point.

8.6×10^{6}

c) If your original number was less than one, put a negative sign in front of the exponent.

8.6×10^{-6}

To test that you understand the steps, convert the number 89,000 into scientific notation. Confirm that the answer is 8.9×10^{4}.

Now do the following conversions:

1) A human cell is 0.000058 meters in size. Express its size in scientific notation: __________

2) Suppose that the national budget surplus is 3.3 trillion dollars ($ 3,300,000,000,000). Express this number in standard scientific notation. _____________

3) Express the following numbers in scientific notation:
The diameter of a human red blood cell is about 0.0075 mm. _______________

The smallest viruses are about 0.000018 mm wide. _______________

4) Write 186,000 in scientific notation: _______________

You should also be able to convert a number in scientific notation into a conventional number. For example, if you should be able to convert the number 5.64×10^{6} into its normal number form.

To do the conversion, you move the decimal point. But there are 4 rules for moving the decimal point correctly:

a) The exponent tells you the number of places to move the decimal point
The exponent in 5.64×10^6 is 6, so you will move the decimal 6 places.

b) If the exponent is negative, move the decimal to the left. If the exponent is positive, move the decimal to the right.
The exponent is positive in 5.64×10^6, so you will move the decimal 6 places to the right.

c) Use zeros to "fill" decimal places if you have to move the decimal beyond the digits.
You will need to add 4 extra zeros to move the decimal 6 places to the right.
5,640,000

To test that you understand the steps, convert the number 2.11×10^{-7} into a normal number. Confirm that the answer is 0.000000211.

Now convert the following scientific notation numbers into conventional numbers.

1) The length of an Argentine ant is 2.4×10^{-1} inches. _______________

2) A redwood tree is 1.37×10^{5} millimeters tall. ___________________________

3) In an average lifetime, your heart may beat 2.94336×10^{9} times: _____________

4) A person is 9.47×10^{-4} miles tall: ______________

f) Graphing data

Imagine a research study was done to test the effectiveness of a new diet. A group volunteers went on the diet for different amounts of time, and they lost more weight the longer they stayed on the diet. The results of the study were:

Time on diet (in days):	Weight lost (in kilograms)
1	0.15
2	0.5
4	0.65
11	0.75
15	1.3
20	1.85

Notice that the results show two types of data: The time spent on the diet (in days) and the weight lost (in kilograms). Also notice the two data types form pairs with each other. For example, 4 days on the diet matches with losing 0.65 kg weight. 9 days on the diet matches with losing 1.25 kg weight, etc. Each matching pair of data is called one **data point**.

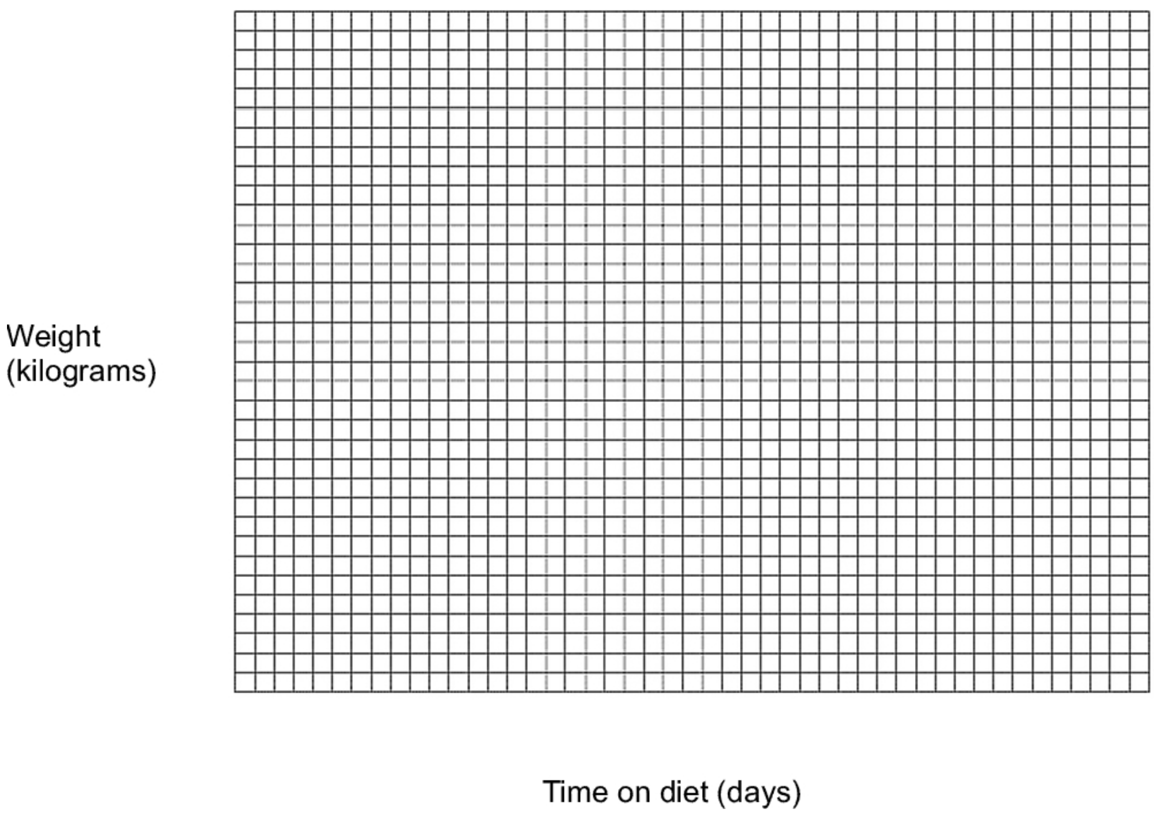
How many data points do the results of this diet study have? ______. The correct answer is six data points.

Results (like the diet results shown above) that contain data points are usually shown as a graph. In this physiology course you will perform several experiments that will require you to present your results in a graph. The steps you must follow to graph your data are given below.

1) Labeling the axis of your graph Graph paper has many straight lines, but the line on the left side and the line on the bottom of the graph paper have special names: Axis. The line on the left side of the graph is called the Y-axis and the line on the bottom of the graph is called the X-axis.

The first step in graphing results is to pick one axis for each of your data types. For example, the "time on diet" data type can be shown on the X-axis and the "weight lost" data can be shown on the Y-axis. (You could have put the time on the Y-axis and the weight lost on the X-axis. There is no right or wrong way of selecting the axis).

Once you pick the data type for each axis, you must always label the axis. This means writing out (a) What is being shown on the axis, and (b) What units it is in. Notice in the graph below that both axes are correctly labeled. Both labels show the type of data and the units of the data for that axis.



2) <u>Numbering the axis</u> The next step is to add numbers to each axis.

Each axis should start at zero. Write a zero at the bottom of the Y-axis and at the left end of the X-axis.

Next you have to add a high number on each axis. This is the step that can be confusing if you are not familiar with making graphs. There is an easy way to add the high number to the axis and a harder way, but the harder way has an advantage later on: It makes the graphing of the data points a little easier.

The easy way of adding the high number to the axis is to simply place your highest data value at the end of the axis.

> *Example:* The highest weight data value is 1.85 kg. Write 1.85 at the end of the Weight axis.

The harder way to add the high number requires two steps. First, round the highest data value up to the nearest "tidy" number.

> *Example:* The highest weight data value is 1.85 kg. The nearest "tidy" number that you can round 1.85 up to is 2.0.

The second step is to find the highest line number on the axis that is a multiple of 10 and then write the "tidy" data value on the axis at that line number.

> *Example:* The weight axis has 35 lines. The highest line number on that axis that is a multiple of 10 is line 30. Write your "tidy" weight of 2 at line 30.

Before we go any further, note that you can make a pair of unit conversion factors for that axis, showing the relationship between lines and data units.

Example: If you placed 2 kg at line 30, your two unit conversion factors are:

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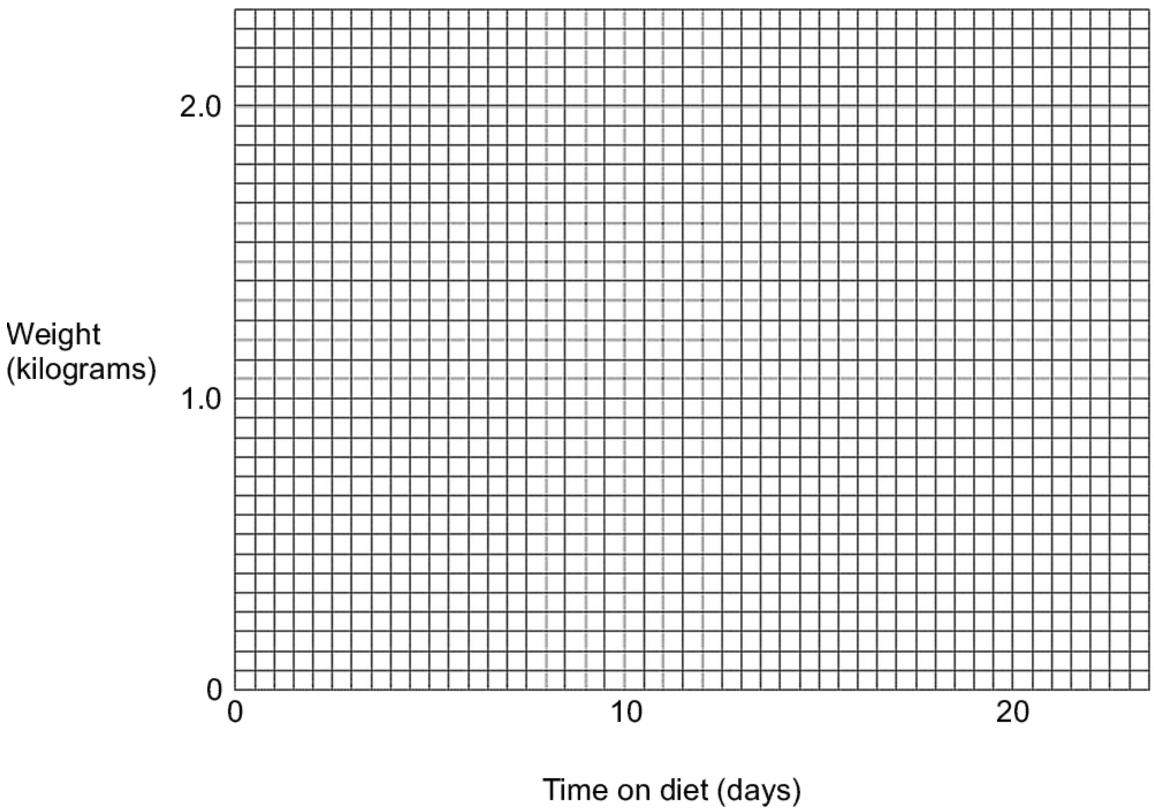
$$\frac{30 \text{ lines}}{2 \text{ kg}} \qquad \frac{2 \text{ kg}}{30 \text{ lines}}$$

Now let's use the same steps to number the X-axis (the Time on Diet axis in this example).

a) The highest value is 20 days.
b) In this case, we do not need to round up to a "tidy" number because the number 20 is already tidy.
c) The X-axis has 47 lines.
d) Line number 40 is the highest line number on the X-axis that is a multiple of 10, so write the 20 days at line 40 on the X-axis.

If you like, you can also number the "half-way" data value on each axis (but this is optional). The graph on the next page shows the graph with correct numbering of the axes.



<u>3) Add the data points to the graph</u> This simply means that you put a dot on the graph for each data point. Each dot must line up with its exact value on the X and the Y-axis. Do **not** use estimation to place data points on the graph. Use the unit factor method to calculate exactly how may lines along each axis the data point is.

For example, the first data point is 1 day and 0.15 kg.

On the Y-axis, the line number for 0.15 kg is calculated as follows:

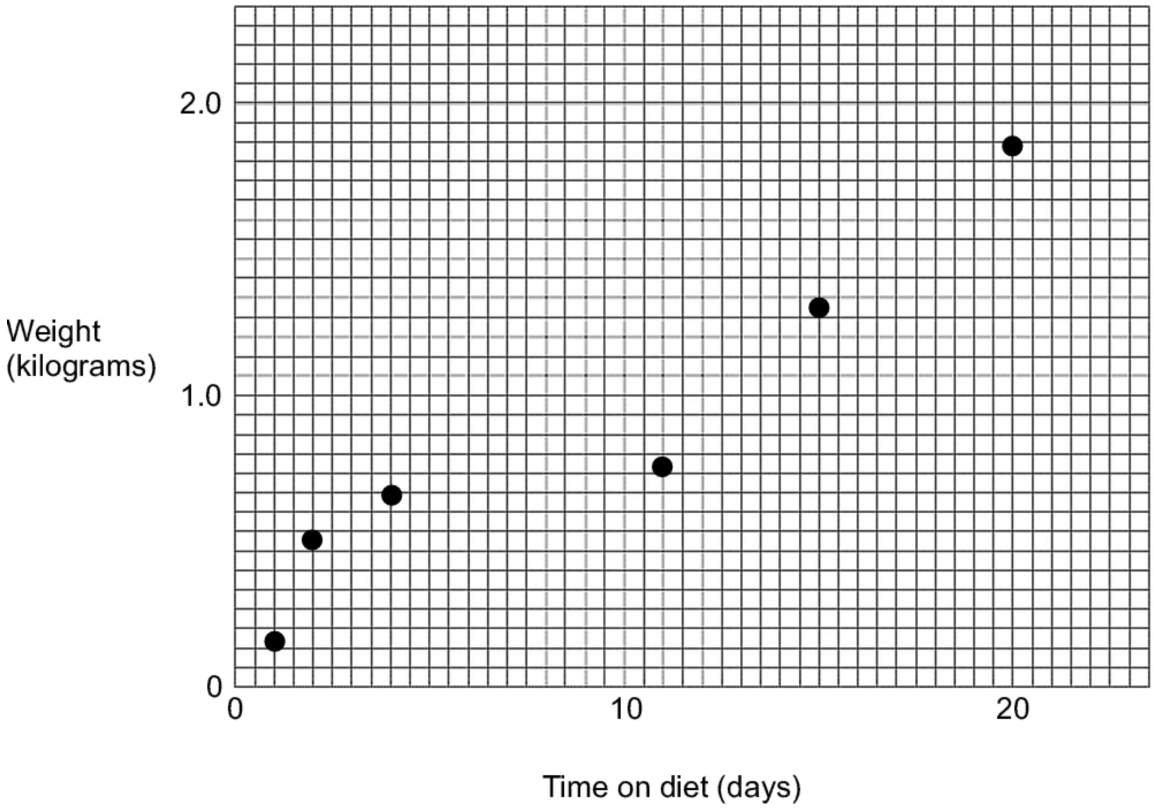
$$0.15 \text{ kg} \quad x \quad \frac{30 \text{ lines}}{2 \text{ kg}} \quad = \quad 2.3 \text{ lines}$$

On the X-axis, the line number for day 1 is calculated as follows:

$$1 \text{ day} \quad x \quad \frac{40 \text{ lines}}{20 \text{ days}} \quad = \quad 2 \text{ lines}$$

So the first data point should be placed on the graph at location X-axis = 2 lines and Y-axis = 2.3 lines. Look at the first point on the graph on the next page and verify for yourself that this is where the first data point is placed.

Using the same unit factor method, all the data points were placed exactly on the graph on the next page.



As an exercise, suppose there was a new data point at 7.75 days and 1.75 kg. Use the unit factor method to calculate the exact X and Y lines for this data point:

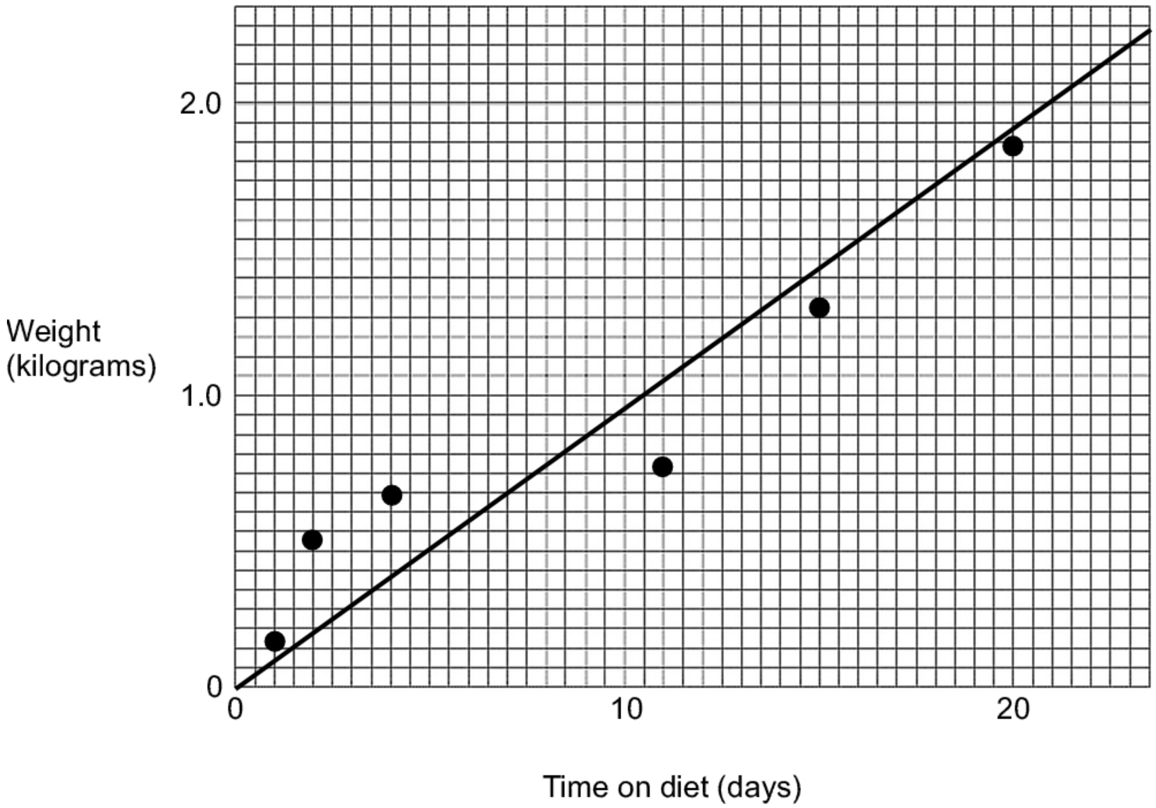
Lines on X-axis: ______ Lines on Y-axis: ______

<u>4) Adding a line through the data points</u> On most (but not all) graphs a line is drawn to connect the data points. You just draw straight lines connecting each data point.

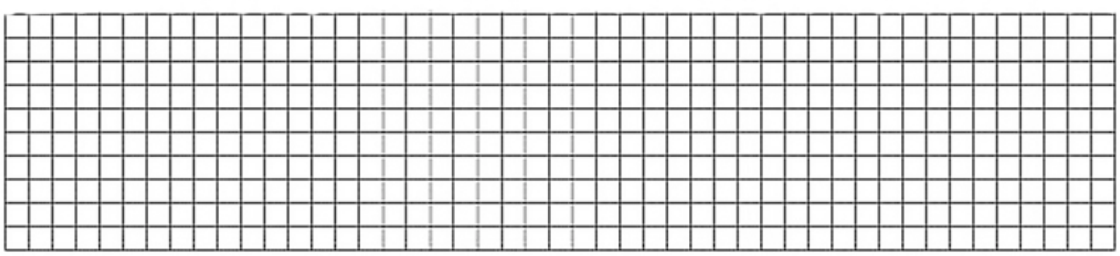
For some graphs, however, you will be asked to draw the "best fit straight line". This is sometimes called linear regression line.

Computers usually are used find the linear regression line, but if you are making a graph by hand, make the linear regression line using a ruler. Draw one single straight line on the graph. The line must (a) go through zero, and (b) have half the data points above the line and half below the line.

On the next page is the same graph with the linear regression line added.



As practice, graph the following data points: (1 cookie, 120 ug blood sugar), (5 cookies, 254 ug blood sugar, (8 cookies, 485 ug blood sugar). Be sure to fully label and number each axis using all the rules discussed in this section. Add the linear regression line to the graphed points. Also, show all six of the unit conversion factor equations that you need to plot the points.



Review Questions

1) Your patient, Mrs. Washington, has been in your care for a week. The doctor has asked you to test the levels of certain substances in her blood during the week. More specifically, the doctor wants you to find the range and average for total cholesterol and TSH (thyroid stimulating hormone) in Mrs. Washington's blood. Here are the results for the week. Study the data and then fill in the ranges and averages at the bottom of her chart.

	Day 1	**Day 2**	**Day 3**	**Day 4**	**Day 5**	**Day 6**	**Day 7**
Cholesterol: (mg/100 ml)	178	210	190	290	165	165	187
TSH: (μg/ml)	1.7	4.4	6.0	8.9	9.5	11.5	12.0

Cholesterol: range = ___________________ average = _____________________
TSH: range = ___________________ average = _____________________

If the normal average for TSH should be 3 μg/ml, by what % is Mrs. Washington's TSH above average?

Use the graph paper on the next page to graph the TSH results from the previous page. Be sure the axis are correctly labeled and numbered and that you make the linear regression line. Also, show all 14 of the unit conversion factor equations that you need to plot the points.

2) a) The class has 57 students. 3 of them have colds. What % have colds? _________

b) 67% of students take more than 2 hours for this lab. If the class has 90 students, how many take more than 2 hours? _________

3) Write the following values in scientific notation:

a) 7951 mg = ___________

b) 0.0000087 μg =___________

c) 1m = ___________

d) The human body is made up of trillions of cells. For the sake of our calculation, let's say the number is 45 trillion cells. Write that number in scientific notation: ______________

4) A person's body weight is 72 kg. Convert this into mg. Write your answer as both a normal number and as a scientific notation number.

_______________ mg (normal number) _____________ mg (scientific notation)

5) A paperclip weighs about 1.7 g. Convert this into ug. Write your answer as both a normal number and as a scientific notation number.

_______________ ug (normal number) _____________ ug (scientific notation)

6) A RBC measures approximately 7.5×10^{-6} meters in diameter. Using scientific notation, express its size in mm and in um. (Hint: First convert 7.5×10^{-6} meters into a normal number, then use unit conversion factors to convert the normal number into mm and um, then convert the mm and um into scientific notation).

___________ mm ___________ um.