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ABSTRACT

In this set of six booklets on graphing, intermediate grade students learn how to choose which kind of graph to make; make bar graphs, histograms, line graphs, and conversion graphs; and use graphs to compare two sets of data. The major emphasis in all Unified Sciences and Mathematics for Elementary Schools (USMES) units is on open-ended, long-range investigations of real problems. In most instances students learn through observing results of their own and their classmates' experiments. However, students may recognize the need for certain facts and/or skills during their investigations. Although some children prefer to work things out for themselves, others may ask for help. USMES "How To Sets" are designed to provide such assistance. Each booklet in a set contains several examples of children using a skill being taught, each example emphasizing a different aspect of the skill or a potential pitfall. The first page tells why or when students may need the skill covered in the booklet and includes a table of contents. There is no sequence to the sets (or booklets within sets) and they should not be used out of the context of childrens' open investigation of a practical problem. (Author/JN)

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USMES
UNIFIED SCIENCES AND MATHEMATICS FOR ELEMENTARY SCHOOLS

HOW TO SET

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CHOOSE WHICH GRAPH TO MAKE

MAKE A BAR GRAPH

MAKE A HISTOGRAM

MAKE A LINE GRAPH

MAKE A CONVERSION GRAPH

USE GRAPHS TO COMPARE TWO SETS OF DATA

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GRAPHING

SE 039 092

WHAT IS USMES?

USMES challenges students to solve real problems within their school and community. Students tackle problems like a busy or unsafe intersection near their school, classroom furniture that doesn't fit them, or playgrounds that are crowded or uninteresting. These problems have immediate and practical impact on students. They have no established, correct solutions--students take or recommend action based upon whatever data they collect and analyze. Furthermore, the students themselves, not the teacher, direct the problem-solving process.

Solving real problems is interdisciplinary: skills, processes, and concepts from science, mathematics, social science, and language arts all play a part. For example, students conduct opinion surveys, build measuring devices, write letters, and make and use graphs. They also make decisions, work productively in small groups, and develop and clarify values.

The USMES curriculum is organized into twenty-six problems, or units, that have been developed in the classroom by teachers and students in a wide variety of schools. Most units can be used in grades K-8 although the level at which students approach a problem and develop a solution will vary according to age, ability, and interest.

RESOURCES FOR AN USMES PROGRAM

In addition to the USMES "How To" Series, there are--

The USMES Guide: This book describes the USMES project, real problem solving, classroom strategies, the Design Lab, the units, and the support materials as well as ways that USMES helps students learn basic skills. A section in the guide correlates the twenty-six USMES units with topics in Science, Mathematics, Social Science, Language Arts, Career Education, and Consumer Education.

Teacher Resource Books (one per unit): Each of these guides to using USMES units describes a broad problem, explains how students might narrow that problem to meet their particular needs, recommends classroom strategies, and presents logs from teachers whose classes have worked on the unit.

Design Lab Manual: This guide helps teachers and administrators set up, run, and use a Design Lab--a place with tools and materials where students can build things they need for their work on USMES units. A Design Lab may be a corner of a classroom, a portable cart, or a separate room.

Background Papers: These papers provide teachers with information and hints that do not appear in the student materials.

The "How To" Series is a resource developed by the USMES project Earle L Lomon, Project Director, Betty M Beck, Associate Director for Development, Thomas L Brown, Associate Director for Utilization Studies, Quinton E Baker, Associate Director for Administration.

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Complete USMES Library ISBN 0-89292-033-5
Intermediate "How To" Series ISBN 0-89292-030-0

THE USMES INTERMEDIATE *HOW TO* SERIES

USMES and Skills

USMES students often see a need to learn new skills to help them get a problem-solving job done. Students seeking to improve a street crossing may want to learn how to use a stopwatch or how to make a trundle wheel. Students comparing different brands of paper towels may want to learn how to design an experiment and how to make a bar graph. The list can go on and on, but the pattern is clear; solving a real problem requires skills.

Purpose of 'How To' Series

Materials that help students learn skills like designing an opinion survey and choosing the appropriate measuring tool are not readily available for intermediate grade students. The USMES Intermediate "How To" Series fills this gap. Its magazine-style format helps students acquire the skills and knowledge they need to do things like redesign their classroom, find the best buy in potato chips, or run a school store.

How to Use the 'How To' Series

Wait for a need. When a student asks for help, refer him or her to the appropriate booklet. Having a student read a booklet before there is a need to do so will not only result in less effective learning but will defeat the USMES purpose of allowing students to decide what needs to be done.

When necessary, use the "How To" Series as a teaching aid. Most of the time students will be able to go through a booklet by themselves and learn the skills they need to learn. However, some material in some sets is difficult and somewhat abstract. When the booklet by itself is not doing the job, feel free to step in and help the student go through it.

Knowing how the contents of the booklets are organized may help in using the series effectively.

- The first page tells why or when a student may need the skill covered in the booklet, and includes a table of contents.
- Each booklet contains several examples or stories about students using the skill or process being taught. Each example emphasizes a different aspect of the skill or a potential pitfall.
- When information in other booklets may help the student, the titles of the booklets are included in the text.
- The last pages of each booklet contain a summary of the points covered in the booklet.

OTHER USMES *HOW TO* SERIES

Beginning "How To" Series: This cartoon-style series covers in less detail much of the same material as the Intermediate Series. Its cartoon-style format helps younger children and those with reading difficulties acquire the skills needed to work on a real problem.

Design Lab "How To" Series: These illustrated cards help children learn how use tools safely and effectively.

"How To" Cards: This series is printed on colored card stock rather than paper. They contain fewer words than the Intermediate "How To" Series and utilize the American system of units (ft./lb./sec.) rather than the metric system. The Collecting Data set, however, is not available in the "How To" Cards.

INTERMEDIATE *HOW TO* SERIES

COLLECTING DATA

Collect Good Data
Round Off Data
Record Data
Do an Experiment
Make an Opinion Survey
Choose a Sample

GRAPHING

Choose Which Graph to Make
Make a Bar Graph
Make a Histogram
Make a Line Graph
Make a Conversion Graph
Use Graphs to Compare Two Sets of Data

MEASURING

Use a Stopwatch
Choose the Right Tool to Measure Distance
Use a Trundle Wheel
Make a Scale Drawing
Find the Speed of Things

SIMPLIFYING DATA

Tell What Your Data Show
Find the Median
Find the Mean
Find the Mode
Find Different Kinds of Ranges
Use Key Numbers to Compare Two Sets of Data

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edc

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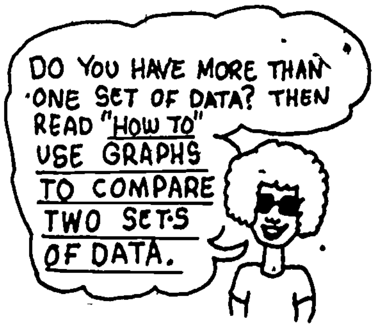
"HOW TO"

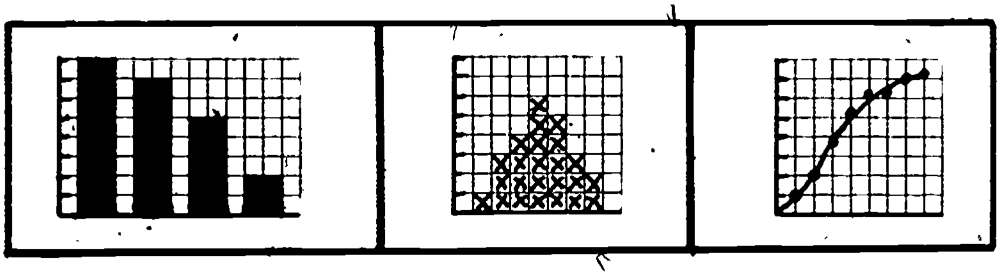
CHOOSE WHICH GRAPH TO MAKE



WHY MAKE GRAPHS?

Suppose that you have made a survey to find out the most popular flavors of soft drink. Or perhaps you have kept notes on the daily temperature for several months. You may have stacks of papers filled with lots of numbers. But lots of numbers can often be confusing.

How can you figure out what all your data mean? One way is to make a graph. A graph is a picture of information.



- Graphs can help you see important things quickly and easily.
- Graphs can help you tell others about your data.
- Graphs can often help you draw conclusions in order to solve problems.

How do you decide which kind of graph to make? It depends. It depends on <u>your</u> data. And it depends on what <u>you</u> want to find out.

Different graphs are made from different data.
Each type of graph will give you different information.

This booklet gives examples of three kinds of graphs. Read the booklet. It will help you decide which graph to make for the data <u>you</u> have and the information <u>you</u> need.

WHAT'S INSIDE — PAGE

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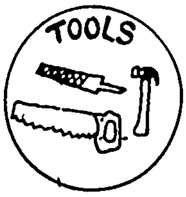
STEPS IN DECIDING WHICH GRAPH TO MAKE

★ 1. DECIDE WHAT KIND OF DATA YOU HAVE.

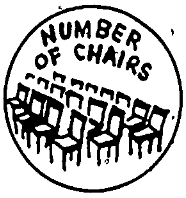
Look at the data you have collected. This collection is called your set of data. It could be numbers or it could be numbers and words.

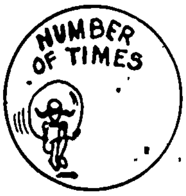
What are the parts of your set of data?

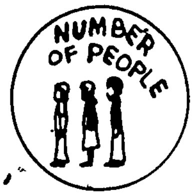
- A list of words? They could be lists of people or tools or foods of months. These can be called SEPARATE ITEMS.



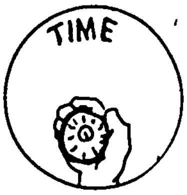
- Numbers? They could be numbers of cars or numbers of children or numbers of times something happens. These can be called NUMBER COUNTS.

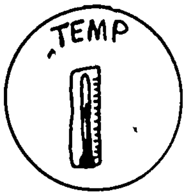




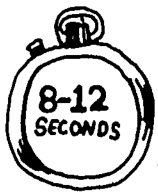


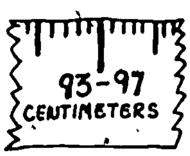
- Times or temperatures or heights or weights? These can be called MEASUREMENTS. You can tell that they are measurements because each number will have a unit, like degrees or centimeters or grams.*





- Sometimes you may want to put your measurements together in clumps, like 8-12 seconds or 41-50 grams or 93-97 centimeters. Then the measurements can be called GROUPED MEASUREMENTS.

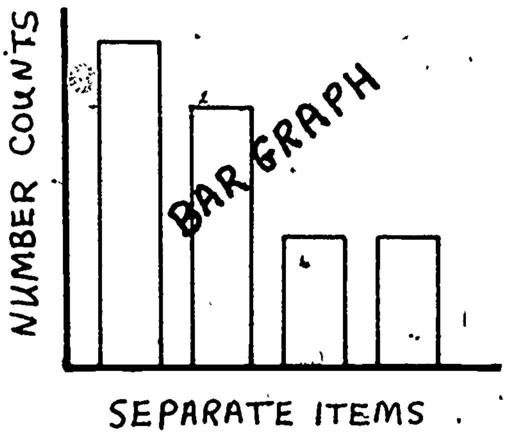


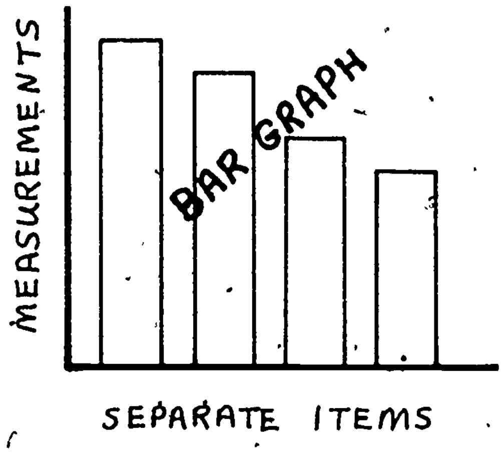


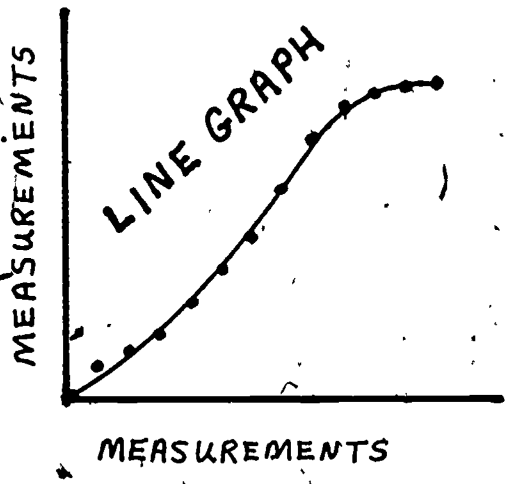
*Sometimes real numbers are treated like measurements in making graphs.

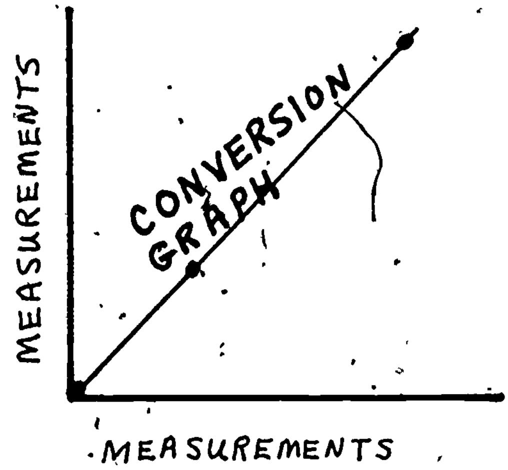
★2. DECIDE WHICH KIND OF GRAPH TO MAKE.

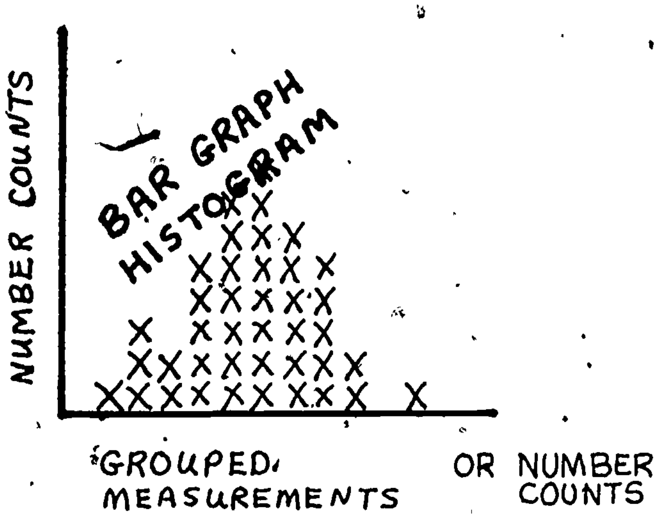
These pictures show what kinds of graphs you can make for different sets of data. The <u>bottom</u> of each graph lists one part of the data. The <u>side</u> of each graph lists the other part.











★3. DRAW YOUR GRAPH.

★4. LOOK AT YOUR GRAPH TO SEE IF YOUR QUESTIONS HAVE BEEN ANSWERED.

Does your graph tell you what you want to know? If it doesn't, you may want to collect more data to add to your graph. Or you may want to make a different graph to give you better information. To do this, you might need to organize your data in another way. Or you may have to collect new data.

FAVORITE DRINKS: A BAR GRAPH

Suppose that your class is planning to sell soft drinks at your school fair. But no one can agree on the kind of drink to serve. You decide to make a survey of students in some other classes to find out which drinks are popular and which are not.

First, you read "How To" Make an Opinion Survey. Then you prepare a list of drinks and ask students to vote for their favorites. When your survey is done, you tally the votes and make a chart of your data.

FAVORITE DRINKS		
DRINK	NUMBER OF VOTES	
ORANGE	𝍸 𝍸 𝍸 𝍸	20
CHERRY	𝍸 𝍸	10
GRAPE	𝍸 𝍸 𝍸 𝍸 ||	22
COLA	||||	4

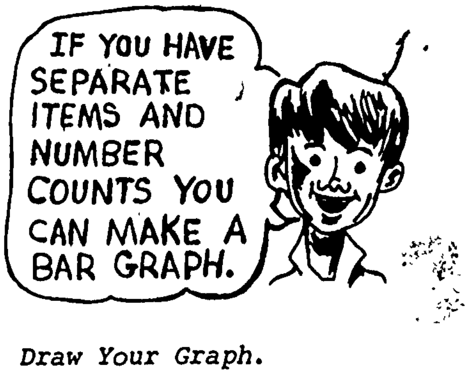
You would like to make a graph to show the results of your survey to others in your class. But first you must decide what kind of graph to make. Here is how to do it.

★ 1. *Decide What Kind of Data You Have.*

You see what part of your data is a list of words. There are four kinds of drink listed: orange, cherry, grape, and cola. That means that one part of your data is a list of SEPARATE ITEMS.

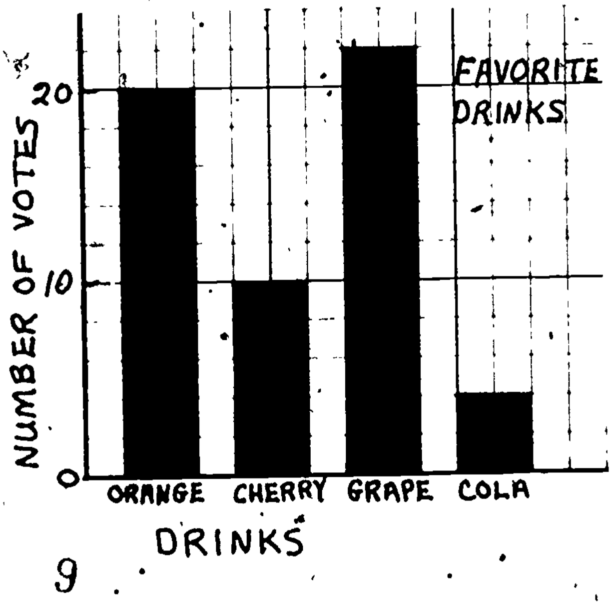
Then you see that you have numbers for the other part of your data. They are the number of votes for each drink. The other part of your data is NUMBER COUNTS.

★ 2. *Decide Which Kind of Graph to Make.*



★ 3. *Draw Your Graph.*

If you need help making a bar graph, read "How To" Make a Bar Graph.



★ 4. *Look at Your Graph To See if Your Questions Have Been Answered.*

The graph tells you that the two highest bars are for grape and for orange drinks. They got the most votes. Your question has been answered. Grape and orange are more popular than either cherry or cola. You might decide to serve either one of them. In fact, you might decide to serve both.

CHALKBOARD HEIGHTS: ANOTHER BAR GRAPH

In the last example, a bar graph was made to show SEPARATE ITEMS and NUMBER COUNTS. In this example, a bar graph is used to show SEPARATE ITEMS and MEASUREMENTS.

Suppose that your class is studying ways to improve classrooms in your school. Some students have complained that the chalkboards are too high for them to reach.

To find out whether the boards are too high, you decide to collect data on the heights of chalkboards in different grades. This chart shows your data.

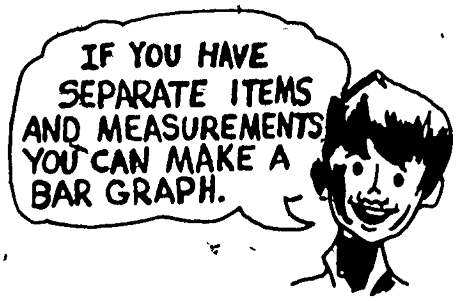
SCHOOL CHALKBOARDS NOV. 7	
Grade	Height of Chalkboards (cm)
K	140
1	156
2	160
3	165
4	170
5	182
6	190

You would like to make a graph to show your data more clearly. Which graph should you make? Follow these steps to find out.

★ 1. *Decide What Kind of Data You Have.*

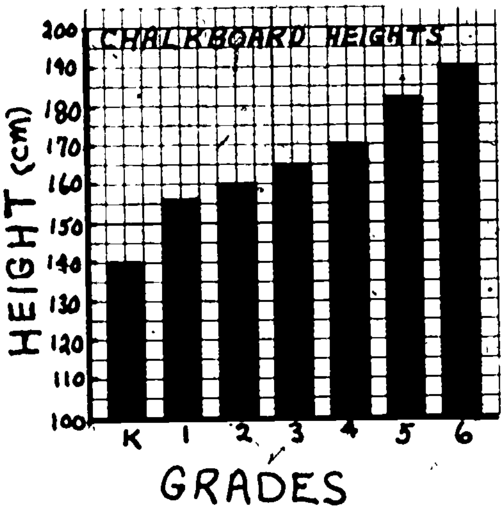
You went into classrooms of seven different grades. You have a list of those grades. That means that SEPARATE ITEMS is one part of your data. Then you measured to find different heights for the boards. The heights were all measured in centimeters. So MEASUREMENTS is the other part of your data.

★ 2. *Decide Which Kind of Graph To Make.*



★ 3. *Draw the Graph.*

You don't have to start the vertical axis at 0. Here the vertical axis begins with 100 cm.



★ 4. *Look at the Graph to See if Your Questions Have Been Answered.*

What does this graph show you? The bars of the graph show that as the grades get higher, the chalkboards get higher. You can tell that you did make the right graph for your data. But did you find out if the chalkboards are <u>too</u> high? The graph doesn't tell you that. Before you can answer that question you need to collect different data. You might collect data on how high children can reach without jumping.

CLASS CROSSING TIMES: A HISTOGRAM

You may make a graph and then find out that it doesn't answer your questions. When this happens, you may be able to regroup your data. Then you can make a different graph that tells you what you want to find out.

Your class may be working on ways to make it easier for children in your school to cross nearby streets. You want to know how long children take to cross one street that runs near your school. You measure the time for each child in your class to cross. As you measure, you round off the times to the nearest second. Then you make a data chart:

CLASS CROSSING TIMES May 3 1:30			
Name	Time to Cross (seconds)	Name	Time to Cross (seconds)
John	5	Marvin	10
Melissa	8	Randy	4
Fred	5	Beryl	6
Chico	4	Felicia	5
Abe	9	Dianne	8
Opal	5	Donny	6
Sam	6	Harold	5
Carol	7	Chuck	7
Suzy	5	May	10
Joanne	12	Pauline	5
Lester	6	Kathy	4
James	5	Nina	7

You look at the chart and notice that the shortest crossing time is 4 seconds and the longest time is 12 seconds.

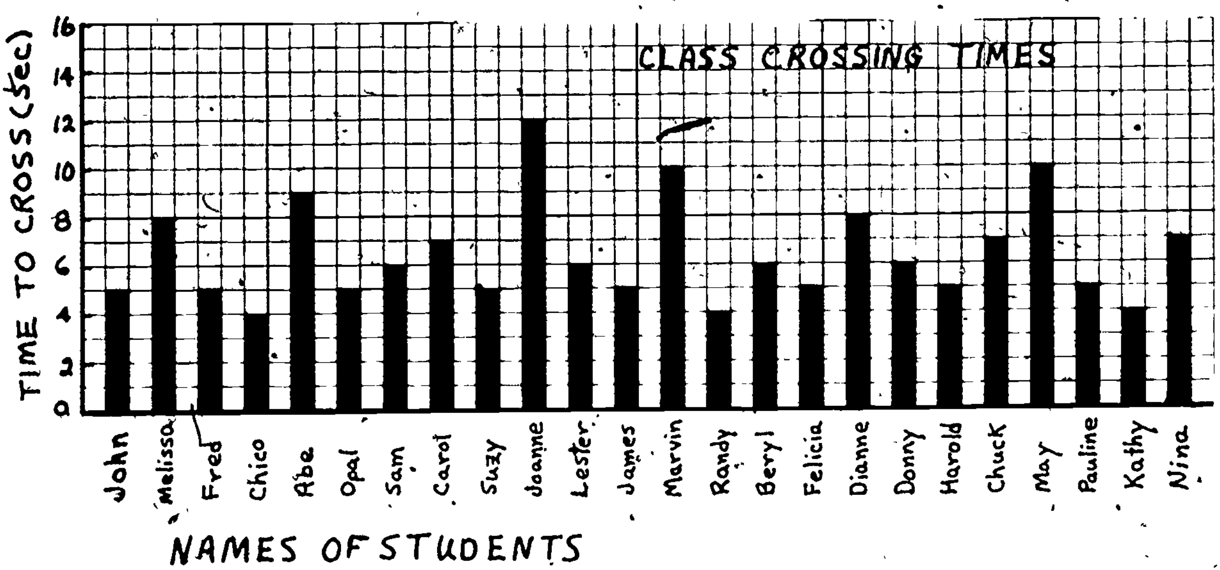
"I wonder what the most common crossing time is," you might think to yourself.

A graph will help you find out. You use your data to draw the graph.

Which graph should you make? First, you look at your set of data. You see that one part of it is a list of children's names. Those are SEPARATE ITEMS. The other part of your data is crossing times. They are MEASUREMENTS.

"Separate items and measurements," you might think to yourself. "I'll make a bar graph."

You use your data to draw the graph. It looks like this.



You look at the graph to see what is the most common crossing time. But you can't tell from the graph. It just shows the crossing time for each student. But you want to find out the time that it took the most students to cross. Perhaps you can organize your data in a different way and then make a graph that will answer your question.

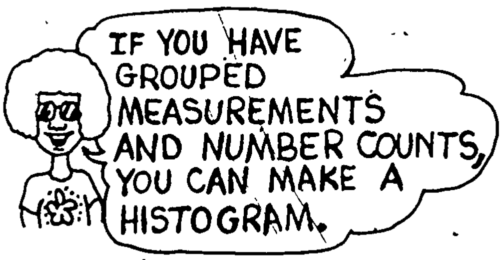
The bar graph shows crossing times. They are MEASUREMENTS. When you first measured the crossing times, you rounded them off to the nearest second. The measurements are really grouped into one-second clumps.

"One part of my data is GROUPED MEASUREMENTS," you think to yourself.

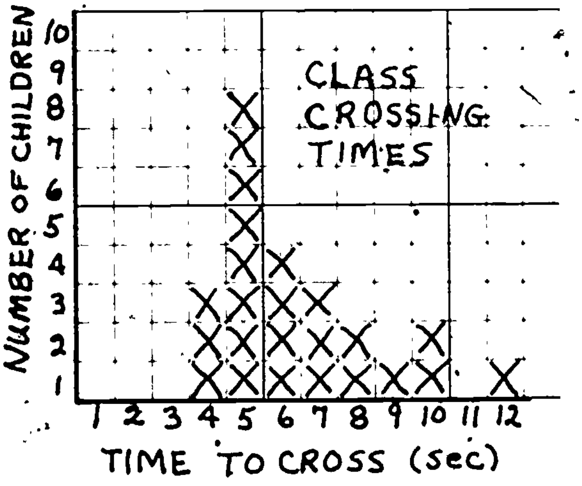
What is the other part of your data? You look at the bar graph and count all the bars for a crossing time of 4 seconds, all the bars for a crossing time of 5 seconds, and so on.

"Now the other part of my data is NUMBER COUNTS," you say.

Which graph can you make if you have GROUPED MEASUREMENTS and NUMBER COUNTS?



Now draw your graph. (If you need help, read the booklet "How To" Make a Bar Graph Histogram.)



Look at your histogram. Does it tell you the most common crossing time? Yes, it does. The bar for 5 seconds is the tallest. That means that 5 seconds is the most common crossing time. Your question has been answered. This graph also tells you that most students can cross in 8 seconds or less.

SCHOOL CROSSING TIMES: ANOTHER HISTOGRAM

In the last example, you made a bar graph histogram by rearranging data from your bar graph. The next example shows how you can make a histogram just from your data chart.

Suppose that after you have studied the crossing times for just your class, you want to find out about the most common crossing times of other children in the school. It would probably be a lot of work to measure the crossing times of every child in your school.

You decide to take a sample from each grade level in the school. Before you begin, you read the booklet "How To" Choose a Sample.

Suppose you decide to use 50 children in your school sample. You measure their crossing times to the nearest second. Your list of 50 crossing times looks like this:

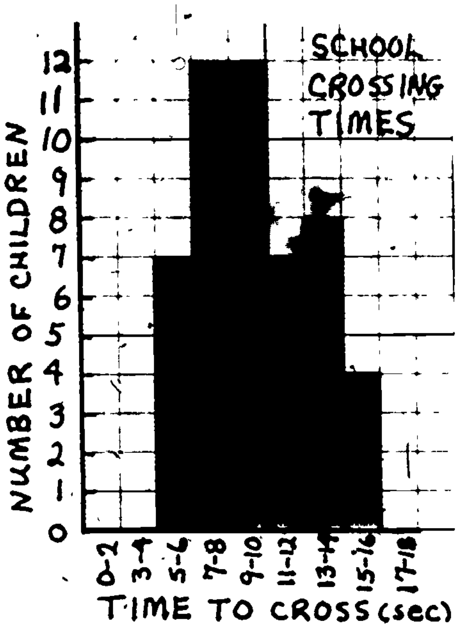
7, 9, 10, 5, 10, 8, 15, 13, 14, 14, 7,
12, 11, 11, 13, 8, 10, 9, 9, 6, 7, 6, 6,
15, 11, 8, 15, 14, 9, 12, 13, 14, 7, 8,
16, 13, 9, 7, 9, 7, 6, 10, 11, 6, 6, 9,
7, 11, 8, 9

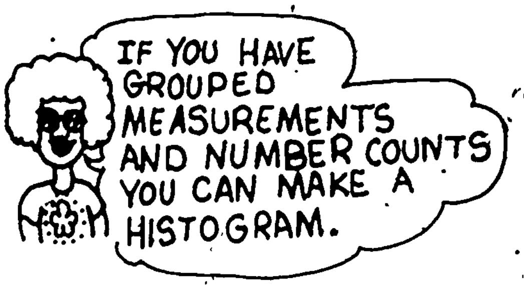
You look at the list and notice that the shortest crossing time for your school sample is 5 seconds. The longest time is 16 seconds. You see that you would need twelve columns if each column stands for 1 second. That's a lot of columns. You decide to put the measurements in groups of 2 seconds.

First you count how many children crossed in 5 or 6 seconds. There are 7. Then you count how many crossed in 7 or 8 seconds. There are 12. You do this all the way up to counting the number of children who crossed in 15 or 16 seconds. Your chart looks like this.

SCHOOL CROSSING TIMES—50 Children-6/4	
Time to Cross (sec.)	Number of Children
5-6	7
7-8	12
9-10	12
11-12	7
13-14	8
15-16	4

Now figure out what kind of graph to make. One part of your data is GROUPED MEASUREMENTS. You also have number tallies. So NUMBER COUNTS is the other part of your data.





Has the graph answered your question? Do you know the most common crossing times for your school sample?

There are two tallest bars. They are for 7-8 seconds and for 9-10 seconds. That means that 7-8 seconds and 9-10 seconds were the two most common crossing times. The graph tells you much more, also. For example, you can tell exactly how many children took longer than 10 seconds or less than 7 seconds to cross.

LETTER SIZES FOR POSTERS: A LINE GRAPH

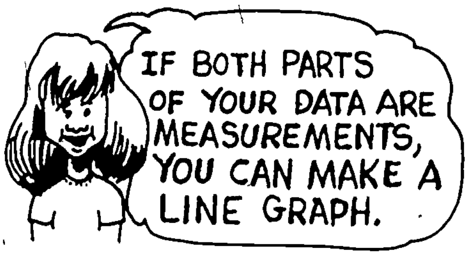
Suppose that your class is making safety posters to hang in the school. How big should the letters be so that the posters can be read easily? One way to find out is to test how far away people can see different sizes of letters.

You may have found out that letters only 2 centimeters high can be read no farther away than 8 meters. Letters that are 3 centimeters high can be read at a distance of 13 meters. After making lots of tests you have this chart:

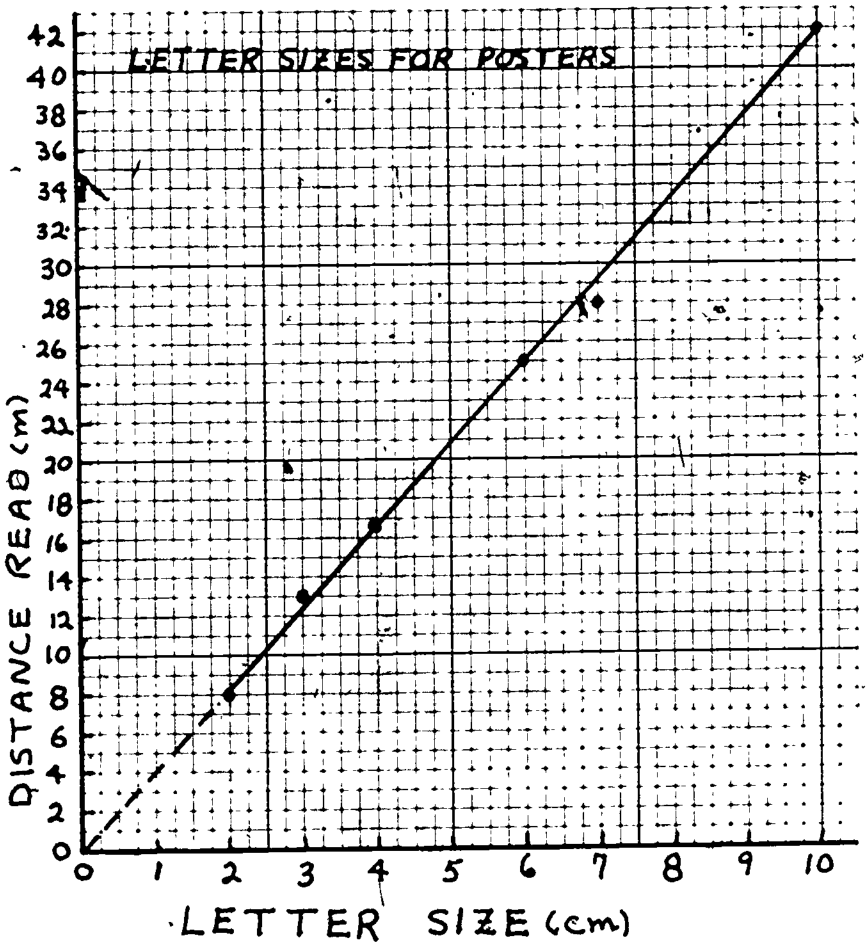
LETTER SIZES FOR POSTERS

LETTER SIZE (cm)	DISTANCE READ (m)
2.	8.0
3.	13.0
4.	16.5
6.	25.0
7.	28.0
10.	42.0

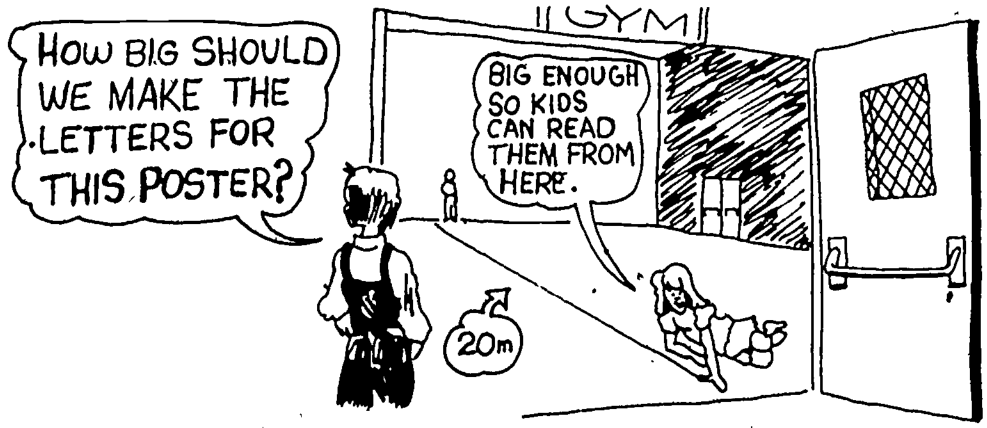
Which graph can you make? You look at your data and see that you have MEASUREMENTS for the letter size and MEASUREMENTS for the distance.



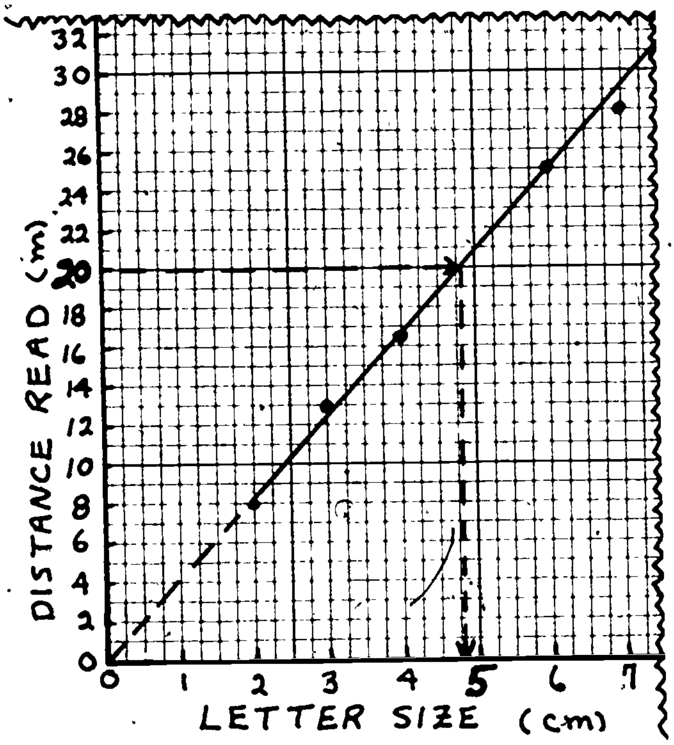
Then draw your graph. (Read "How To" Make a Line Graph if you need help.)



Now suppose you want to hang the posters so that they can be seen from at least 20 meters away. How big do you have to make the letters?



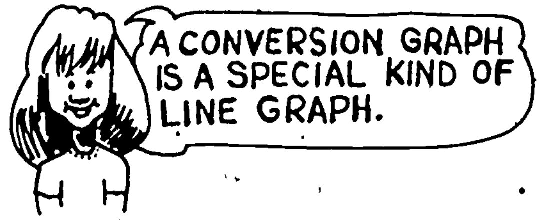
You can find out by reading the graph. It shows that you should make your letters about 5 centimeters high if you want them to be read at a distance of 20 meters.



This line graph can tell you the letter size you need for any distance. It can also tell you the distance at which any letter size can be read. A line graph can help you find extra information that you didn't have when you started.

CUPS TO OUNCES: A CONVERSION GRAPH (A SPECIAL LINE GRAPH)

Suppose that your class is going to make punch to sell to other classes. You may have taken orders for 14 cups one day. You wonder how many fluid ounces of punch you will need in order to make 14 cups. A conversion graph will help you find out.

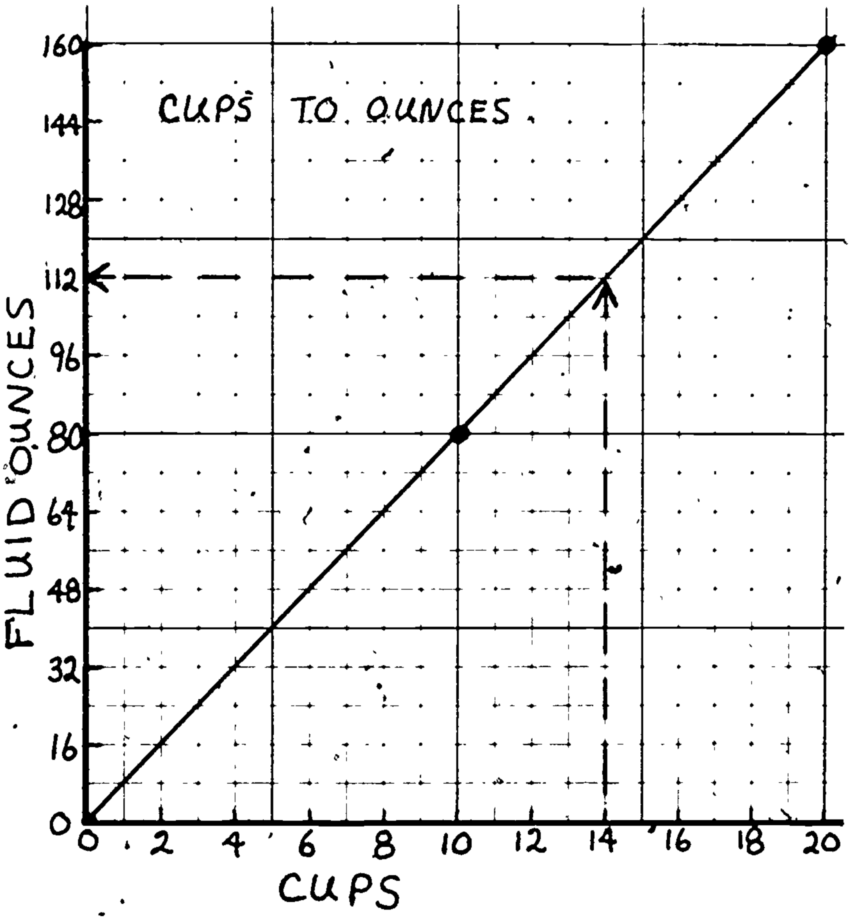


To make a conversion graph, you need to know three sets of measurements. For this problem you do. You know that 0 cups equals 0 fluid ounces. And you know that 1 cup equals 8 fluid ounces. That tells you that 10 cups equals 80 fluid ounces and that 20 cups equals 160 fluid ounces.

Both parts of your data are MEASUREMENTS (cups and fluid ounces). So you know that you should make a line graph.

Draw your graph. (<u>"How To" Make a Conversion Graph</u> will help you do this.)

CUPS	FLUID OUNCES
0	0
10	80
20	160



The graph has answered your question. It tells you that for 14 cups, you will need to make 112 fluid ounces. Now that you have made this graph it can help you with other problems, too. Whenever you need to change from cups to ounces or from ounces to cups, you can use your graph.

MAKING YOUR OWN GRAPHS

So far, you have read about how to choose the graph that both fits your data and answers your questions. Here is a checklist to help you choose the right graph.

1. DECIDE WHAT KIND OF DATA YOU HAVE.

   Do you have separate items?

   Do you have number counts?

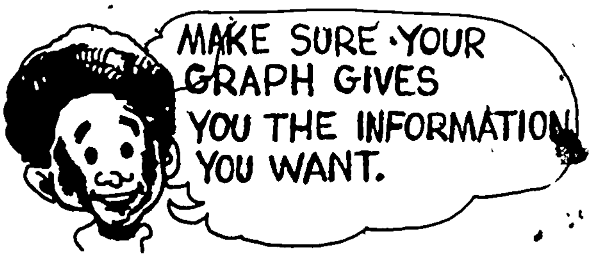
   Do you have measurements? Can your measurements be put into groups?

2. DECIDE WHICH KIND OF GRAPH TO MAKE.

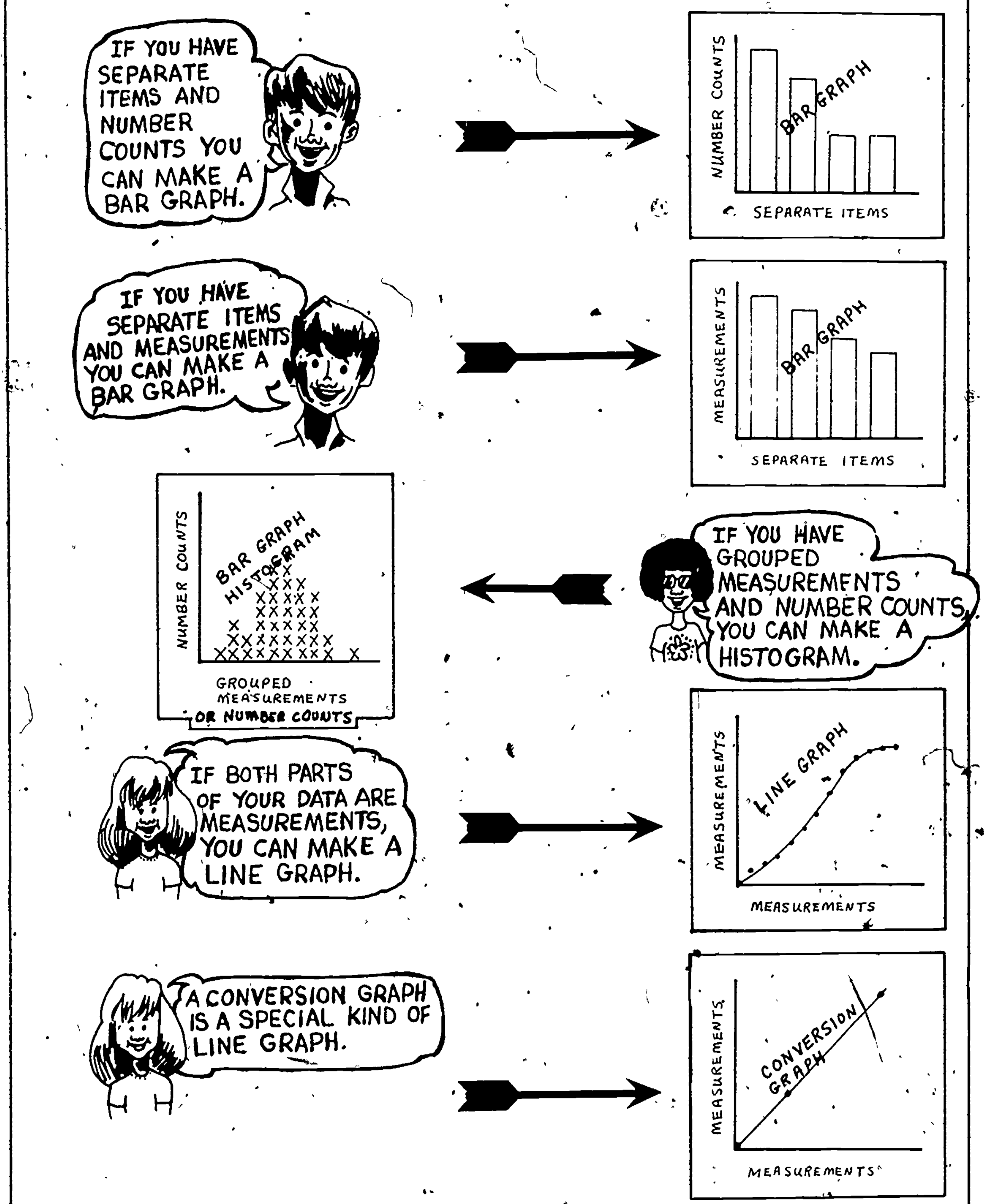
3. DRAW YOUR GRAPH.

4. LOOK AT THE GRAPH TO SEE IF YOUR QUESTIONS HAVE BEEN ANSWERED.

   Does your graph tell you what you want to know? Do you need to collect more data to add to your graph? Do you need to collect new data? Do you need to reorganize your data and make another kind of graph?



ERIC



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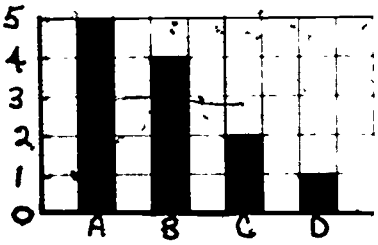
"HOW TO"

MAKE A BAR GRAPH

WHAT IS A BAR GRAPH?

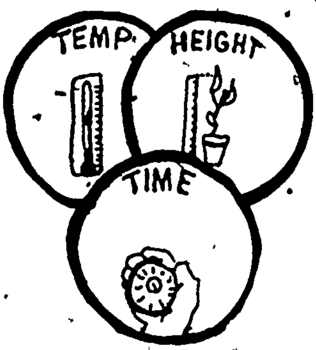
- It is a simple picture of separate items. Each bar stands for a different thing. The height of the bar tells how many or how much.



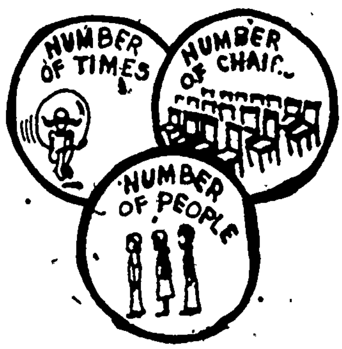
WHEN SHOULD YOU MAKE A BAR GRAPH?

- You can make a bar graph when your data are SEPARATE ITEMS and NUMBER COUNTS or SEPARATE ITEMS and MEASUREMENTS.

SEPARATE ITEMS

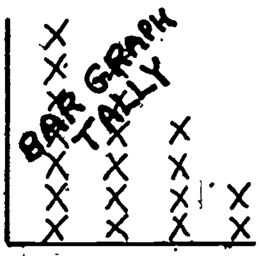


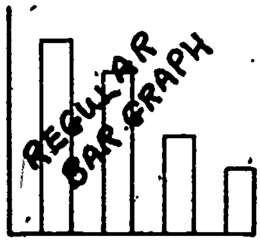
MEASUREMENTS

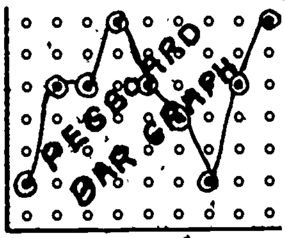


NUMBER COUNTS

THERE ARE THREE KINDS OF BAR GRAPH.







This booklet will show you how to make each of these kinds of bar graph.

WHAT'S INSIDE PAGE

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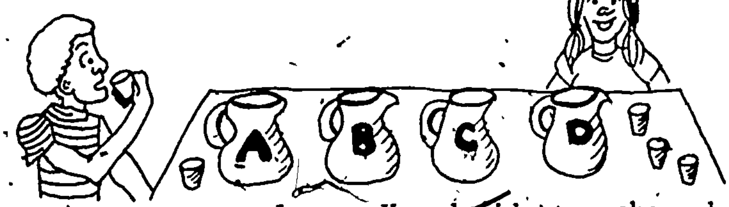
A BAR GRAPH TALLY: TESTING DRINKS

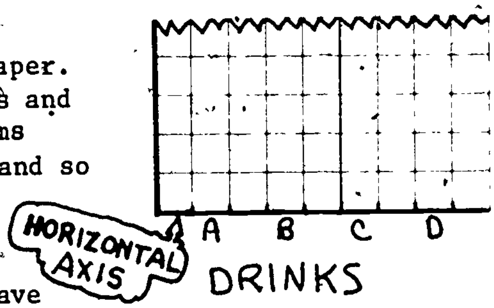
Sometimes you may need to keep a running count about something. For example, you might want to keep track of the numbers that come up when you toss a die several times. You might want to tally the number of "yes" answers to a survey questionnaire. Or you might want to keep a count of which drinks students in your class like best.

There is an easy way to collect your data and make a graph at the same time: make a BAR GRAPH TALLY. This example shows how to do it.

Suppose that your group will be making drinks for your class party. You want to find out the favorite drink of the children in your class. You set out four different drinks on a table. You label each drink with the letter A, B, C, or D. The students will taste each of the drinks and then vote for the one they like best.

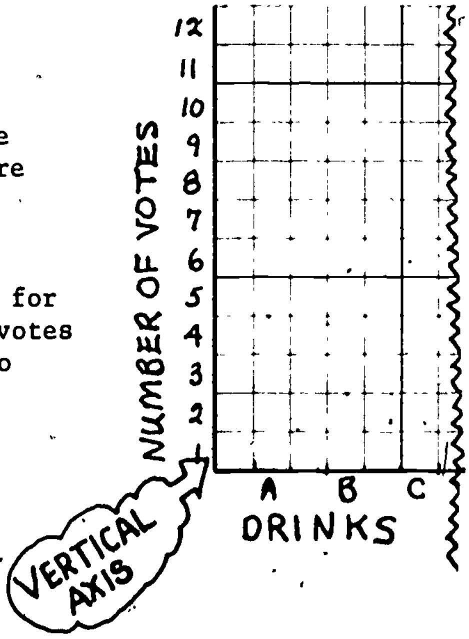


You want to count the votes as you go along. You decide to make a bar graph tally. Here is how to set it up.



First, draw two lines on a piece of graph paper. Be sure to leave room to write in the labels and the numbers. You will put the separate items along the bottom line, or horizontal axis, and so you label it DRINKS.

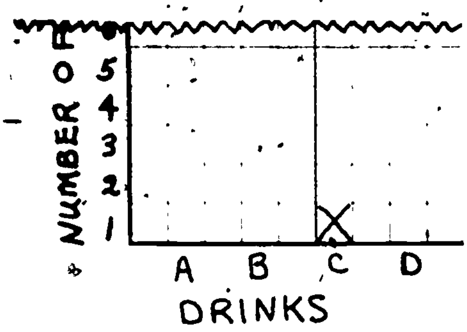
In the spaces along the horizontal axis you write the letters of the drinks. If you leave a space between the letters, your bars will be easier to see.



You will put the number counts along the side line, or vertical axis. The number counts are the number of votes. You label the vertical axis NUMBER OF VOTES.

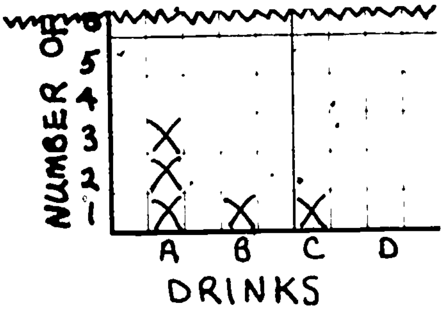
Then you put numbers along the vertical axis for how many votes. Because you will tally the votes as you go along, your graph will have Xs. So write the numbers <u>beside the spaces</u>.

You have set up your graph. Now you are ready to make the tally. Suppose Jill comes up first. She tastes each drink. "I like Drink C best," she says. You put an X in the first box above Drink C. That stands for Jill's vote.



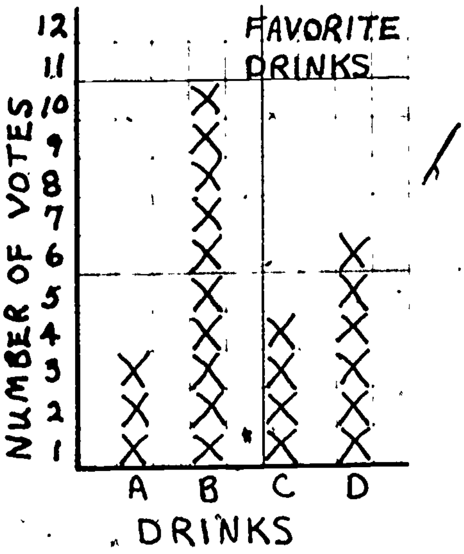
Then suppose Beth comes up to taste the drinks. She votes for Drink B. You put an X in the column for Drink B.

Then suppose Jim, Sam, and Mark all vote for Drink A. You put three Xs in the boxes above Drink A. Now your graph looks like this.



Then you go on. Each time a child votes, you put an X in the correct column. When all the students have voted, the graph looks like this:

You look at the graph. You can see that the bar for Drink B is the highest. Drink B is the favorite. You can also tell how many votes each drink received. Just follow the top X of each bar to the number at the side. Drink A got 3 votes, Drink B got 10 votes, Drink C got 4 votes, and Drink D got 6 votes.



REGULAR BAR GRAPHS: WALK LIGHTS

There are times when you want to graph the MEASUREMENTS of people, animals, or things. For example, you might have data about the weights of different animals or the heights of chalkboards, or the times 5 children take to run 100 meters.

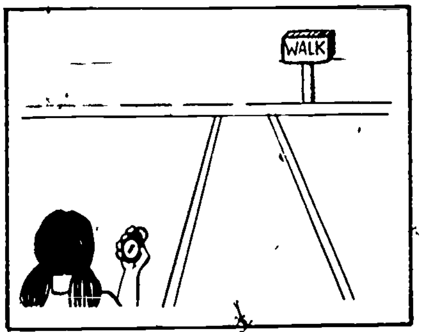
In this example, you will find out how to make a bar graph to show SEPARATE ITEMS and MEASUREMENTS. You will also find out what to do if you don't have enough room to write all your numbers.

Suppose that your class is studying how to make school crossings safer. You are on the Traffic Light Committee. You want to find out how long the WALK signs stay on before they change to DON'T WALK signs.

You go to six busy streets that intersect Main Street. Let's say that the names of the streets are Ash Street, Oak Street, Cedar Street, Pine Street, Elm Street, and Fir Street. With a stopwatch, you measure the number of seconds that each WALK light stays on. You round off the times to the nearest second.

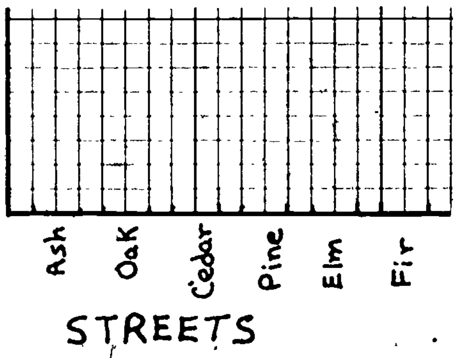
Here is your data chart:

WALK LIGHTS	APRIL 8
STREET	TIME WALK SIGN STAYED ON (Seconds)
ASH	25
OAK	18
CEDAR	30
PINE	15
ELM	18
FIR	24



The names of the streets are SEPARATE ITEMS. The times the WALK sign stayed on are MEASUREMENTS. You know that you can make a bar graph to show your data. Here is how to do it.

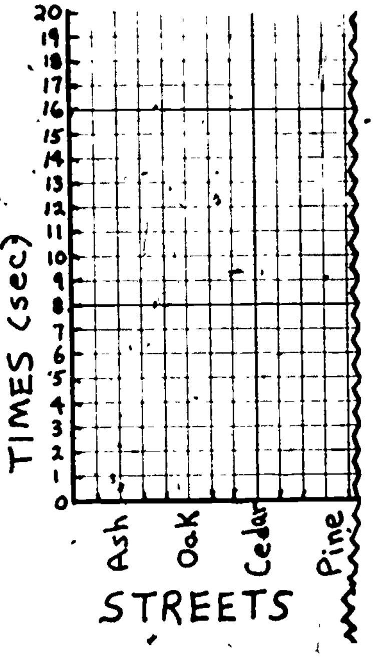
Draw two lines on graph paper. Be sure to leave room to write in the labels and the numbers. On the horizontal axis you will put the names of separate streets. You label the horizontal axis STREETS and write the names of the streets beside the spaces. You can put the names of the streets in any order you want.

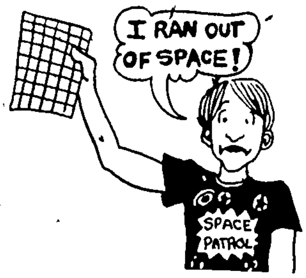


Along the vertical axis you will put the measurements you have found. These are the number of seconds that the WALK lights stayed on. Label this axis TIMES (seconds).

Now you are ready to write the numbers. Your graph will have bars, not Xs, so you write a number next to each line along the TIMES axis. You begin to fill in the numbers.

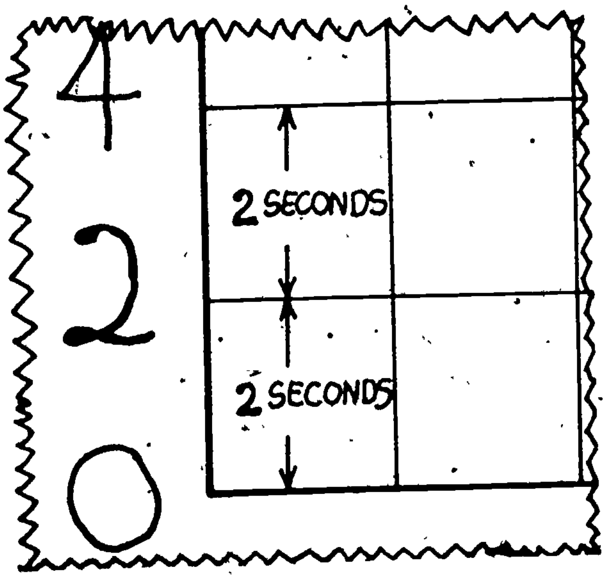
Something is wrong. You can fit only 20 seconds on the TIMES axis. But several of the times listed on your data chart are all longer than 20 seconds. You have no more space on your graph paper. What should you do?

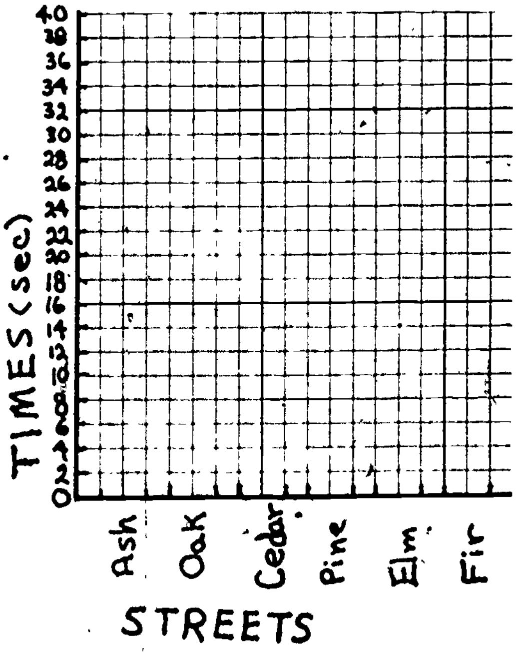




Look again at your data chart. The longest time listed is 30 seconds for the WALK light on Cedar Street. You can use only 20 spaces on the vertical axis of your graph paper.

Divide the longest time by the number of spaces. Thirty divided by 20 is 1½. You could let each space stand for 1½ seconds, but that would be awkward. Instead, you can let each space stand for 2 seconds. That way, you will be able to fit in the largest number and all the others, too. The vertical axis can go up to 40.

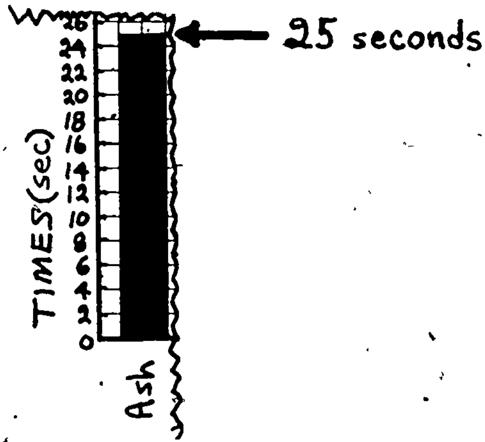




Now you are ready to put the bars on your graph. First look at the data chart:

WALK LIGHTS	APRIL 8
STREET	TIME WALK LIGHT SIGN STAYED ON (seconds)
ASH	25

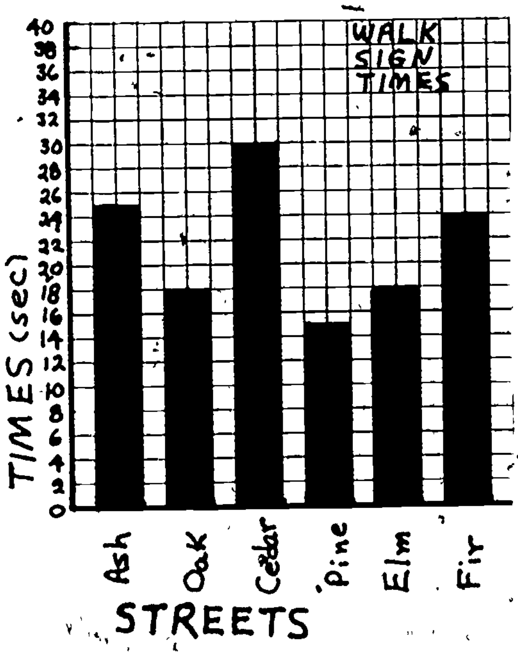
The data chart shows that the time for Ash Street is 25 seconds. That means that the top of the bar will be halfway between the mark for 24 seconds and the mark for 26 seconds. Draw a horizontal line at that place and then make the bar come down to the bottom of the graph.



Then draw the bars for the rest of the data on your chart. Make sure that the top of each bar lines up with the right numbers on the side of the graph. Make up a title for your graph so that others will know what it is about. The finished graph looks like this.

The graph shows your data in a clear way. You can easily spot the tallest bar and the shortest one. The Cedar Street WALK light stayed on longer than any of the others. The Pine Street WALK light stayed on shortest time. You can tell from the graph that the Cedar Street WALK light stayed on twice as long as the one on Pine Street.

This graph gives you a lot of other information, too. In fact, you can compare times and read off the exact measurements just by looking at the bars of the graph.

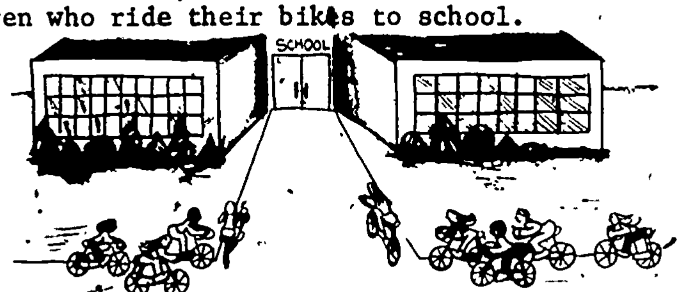


REGULAR BAR GRAPHS: RIDING BIKES

You can make a regular bar graph when your data are SEPARATE ITEMS and NUMBER COUNTS. These might be the number of servings of different foods that are thrown away each day. They might be the numbers of different animals sighted on a nature trail one day. Or they might be the number of students who ride their bikes to school.

In this example, you will find out how to make a regular bar graph for SEPARATE ITEMS and NUMBER COUNTS. You will also learn how to put your columns into an order that makes sense for your problem.

Let's say that your school has just bought several bicycle racks. Your class has been asked to help decide where the racks should be placed so that they will be useful to children who ride their bikes to school.



Suppose that Todd, Paul, Lisa, and you each go to a different classroom. You go to grades 3, 4, 5, and 6. You count the number of children who say that they usually ride their bikes to school. Then each person in your group fills in one line of the data chart.

Suppose that Todd comes back first. "Ten children in grade 5 ride their bikes to school," he reports. He writes that on the data chart.

Then Lisa reports her data. "Twelve children in grade 6 ride their bikes to school," she says.

Then Paul and you report your data. The chart looks like this.

RIDING BIKES TO SCHOOL MAY 8

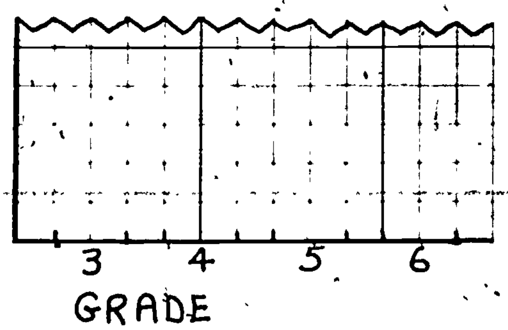
Grade	Reporter	Number of Children
3	You	4
4	Paul	7
5	Todd	10
6	Lisa	12

You can make a bar graph to show the data to others in your class.

First set up the graph. Draw two lines. Label the horizontal axis GRADE.

Put the separate grades beside the spaces. But don't write them in any old way.

You should write the grades in order from lowest to highest. Doing that will give you more information than just writing them in any order.

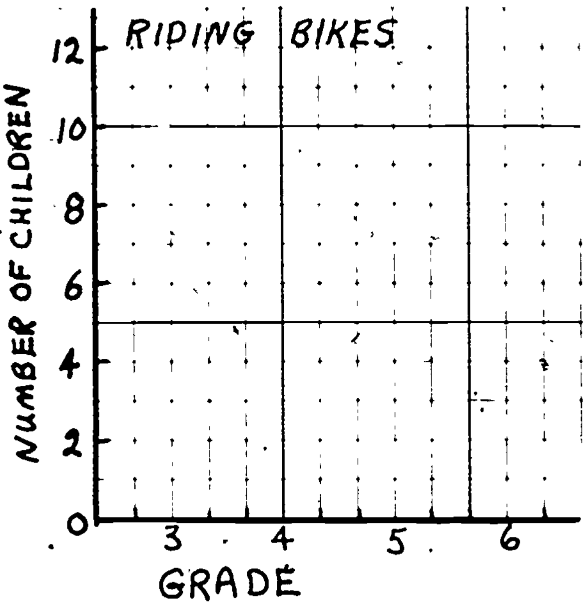


Next, label the vertical axis NUMBER OF CHILDREN. The largest number in your chart is 12.

Check to see if you have enough spaces on your graph paper. You do. You can let each space stand for one child.

Then write in the numbers next to the lines. The tick marks will show which lines the numbers stand for. You don't have to number every line.

Make up a title for your graph. Now you are ready to draw the bars.

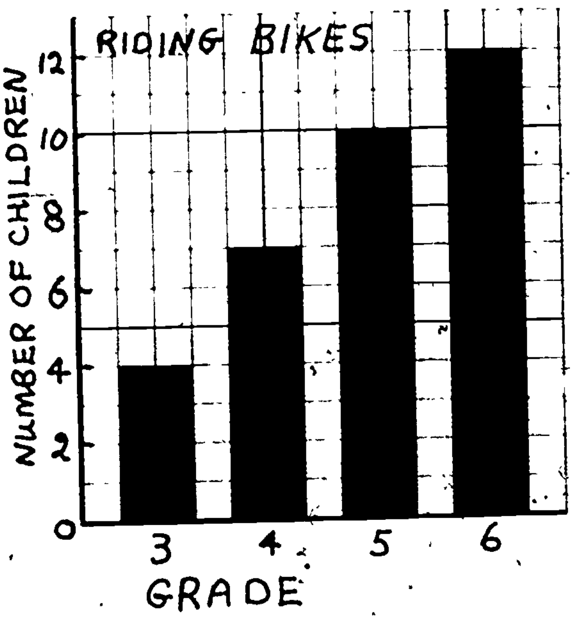


Using your data chart, make one bar for each grade level. Be careful to draw the bars so that they line up with the right lines for the number of children. Here is the finished graph.

You look at the graph and see that the bars get higher as the grade levels get higher. (Putting the columns in order helped you see that.)

It is easy to see that more fifth and sixth graders ride their bikes to school than third and fourth graders. You can tell the exact numbers of children for each grade.

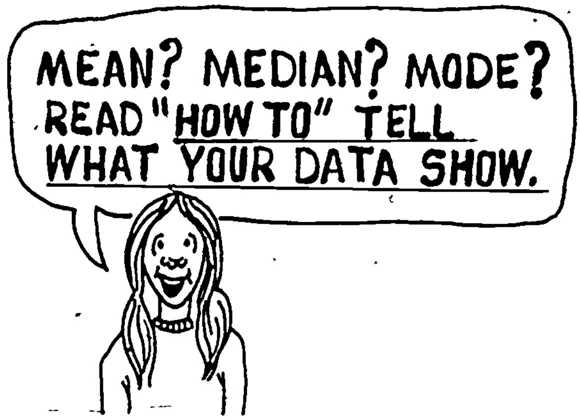
This graph may help you decide where to place the bike racks.



REGULAR BAR GRAPHS: A PLANT EXPERIMENT

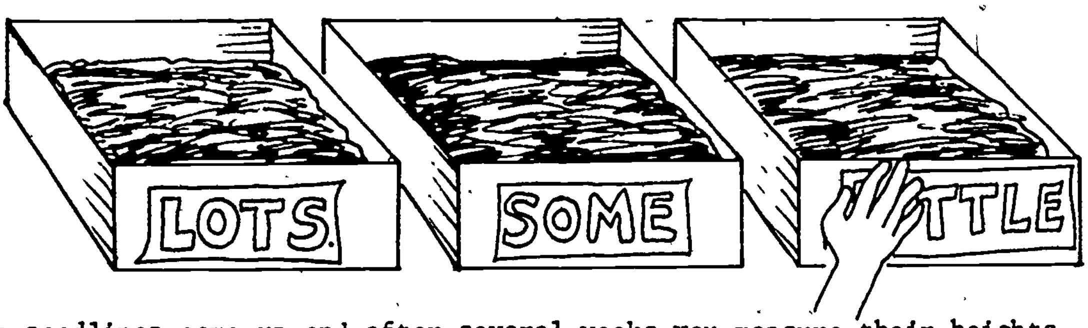
Sometimes you have to do something to your data before you can make a bar graph. For example, if you wanted to show spelling test scores of five different classes, you might decide to take the mean test score of each class. Then you would have one number for each class. Or if you wanted to compare favorite games in different grades, you might take the mode for each grade.

This example shows how you can use the median of your sets of data to make a bar graph.



Suppose that you are doing an experiment to find out if light makes your plants grow taller. You have read "How To" Do an Experiment.

Let's say that you have planted three boxes of seeds. You give one box of seeds a lot of light. You give another box of seeds some light. You give the third box of seeds hardly any light at all. You put a label on each box to show the amount of light it is given.



The seedlings come up and after several weeks you measure their heights. Instead of measuring all the seedlings, you will take a sample from each box.

First you read "How To" Take a Sample. Then you choose six seedlings from each box and measure their heights in centimeters. Here are your results.

LOTS OF LIGHT 6/12	
PLANT	HEIGHT (cm)
#1	5
#2	12
#3	6
#4	9
#5	8
#6	8

SOME LIGHT 6/12	
PLANT	HEIGHT (cm)
#7	10
#8	6
#9	11
#10	6
#11	7
#12	4

LITTLE LIGHT 6/12	
PLANT	HEIGHT (cm)
#13	3
#14	2
#15	1
#16	4
#17	6
#18	4

You want to make a bar graph to show your results to others. But drawing 18 bars to show each of the heights is a lot of work and might not even give you the information you want.

Instead, you decide to find the median heights of the plants in each of the boxes. The median is the middle number for each set of data. (If you need help, read "How To" Find the Median.)

LOTS OF LIGHT 6/12		
PLANT	HEIGHT (cm)	
#1	5	MEDIAN HEIGHT: 8cm
#2	12	
#3	6	
#4	9	
#5	8	
#6	8	

SOME LIGHT 6/12		
PLANT	HEIGHT (cm)	
#7	10	MEDIAN HEIGHT: 6.5cm
#8	6	
#9	11	
#10	6	
#11	7	
#12	4	

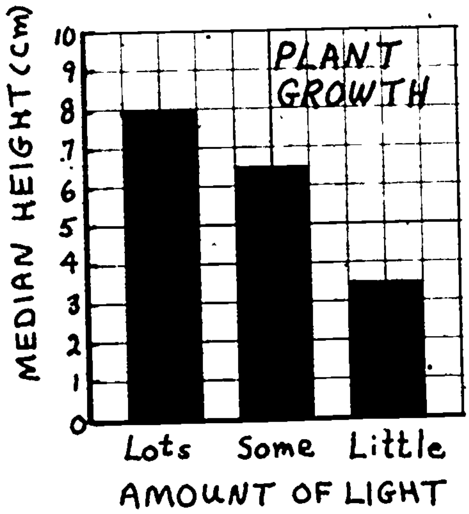
LITTLE LIGHT 6/12		
PLANT	HEIGHT (cm)	
#13	3	MEDIAN HEIGHT: 3.5cm
#14	2	
#15	1	
#16	4	
#17	6	
#18	4	

Now set up the bar graph. Label the horizontal axis AMOUNT OF LIGHT.

Then put the columns in order from the most light to the least light. (You can also put them in order from the least light to the most light. The important thing is to put them in an order which will let you see more about what you have measured.)

Write LOTS, SOME, and LITTLE beside the spaces along the horizontal axis.

Label the vertical axis MEDIAN HEIGHTS (cm) and write the numbers for the measurements. Then fill in the graph.

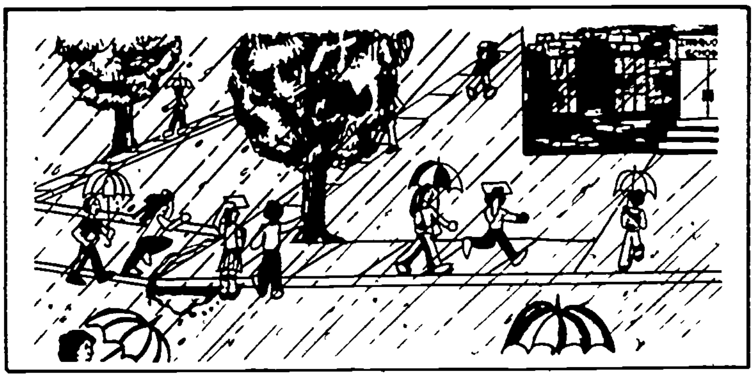


A comparison of the bars of the graph shows the differences in the median heights of the three groups of plants. Look at the shortest bar. It shows that plants grown with little light had a median height of only 3.5 centimeters. The tallest bar is at 8 centimeters. That is the bar for plants grown with lots of light.

A PEGBOARD BAR GRAPH: BAROMETRIC PRESSURE

There are times when you can make a kind of bar graph on a pegboard, instead of on graph paper. You can make the graph at the same time you collect your data. Here is an example of how to do it.

Suppose that your class is studying weather. You have heard weather forecasters say that when the atmospheric pressure falls, it is likely to rain. You want to test this idea.



You decide to keep track of newspaper reports of barometric pressure as measured in inches of mercury. Let's say that you do this for the whole month of March. Here is how to set up a pegboard graph as you collect your data.

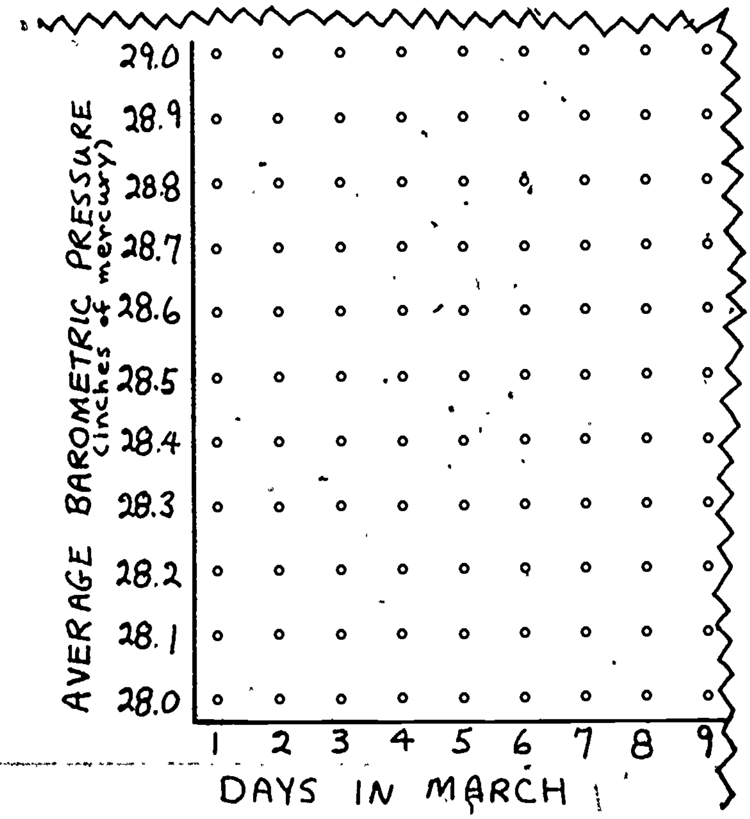
Label the bottom of the pegboard DAYS IN MARCH. Each column of pegs will stand for one of the days.

There are 31 days in March. Write the numbers from 1 to 31 along the horizontal axis.

Along the side of the pegboard write AVERAGE BAROMETRIC PRESSURE (inches mercury). Normal sea level pressure is about 30 inches mercury; so you don't have to start labeling the numbers from 0.

In this example, the graph starts with 28.0 inches. Each row goes up by 0.1 inch.

Now your pegboard graph is ready to be filled in day by day.



Each day you will hang a peg to show the average barometric pressure.

You will hang a colored peg if the day is rainy.

If the day is not rainy, you will hang a plain peg.

Suppose that you have data for the first four days in March.

BAROMETRIC PRESSURE AND RAIN IN MARCH

DAY	AVERAGE PRESSURE (inches of mercury)	RAIN/ NO RAIN
1	28.6	No rain
2	29.5	Rain
3	29.5	No rain
4	29.4	Rain

Here is what your graph looks like for these four days.

The first day was not rainy and the pressure was 28.6 inches. You hang a plain peg in the first column at 28.6 inches.

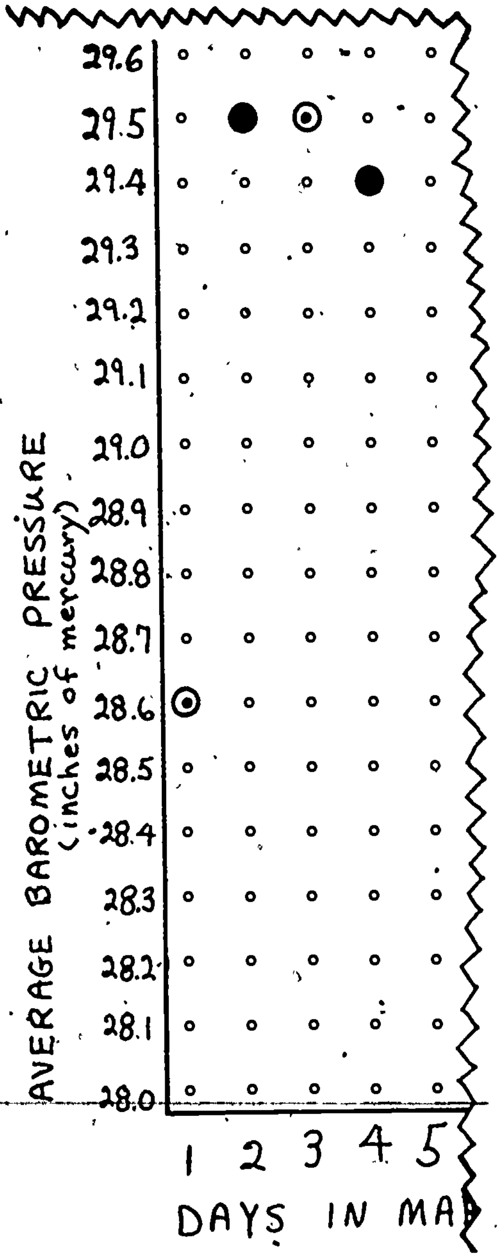
To show the second day, you hang a colored peg in the second column at 29.5 inches.

To show the third day, you hang a plain peg at 29.5 above Day 3.

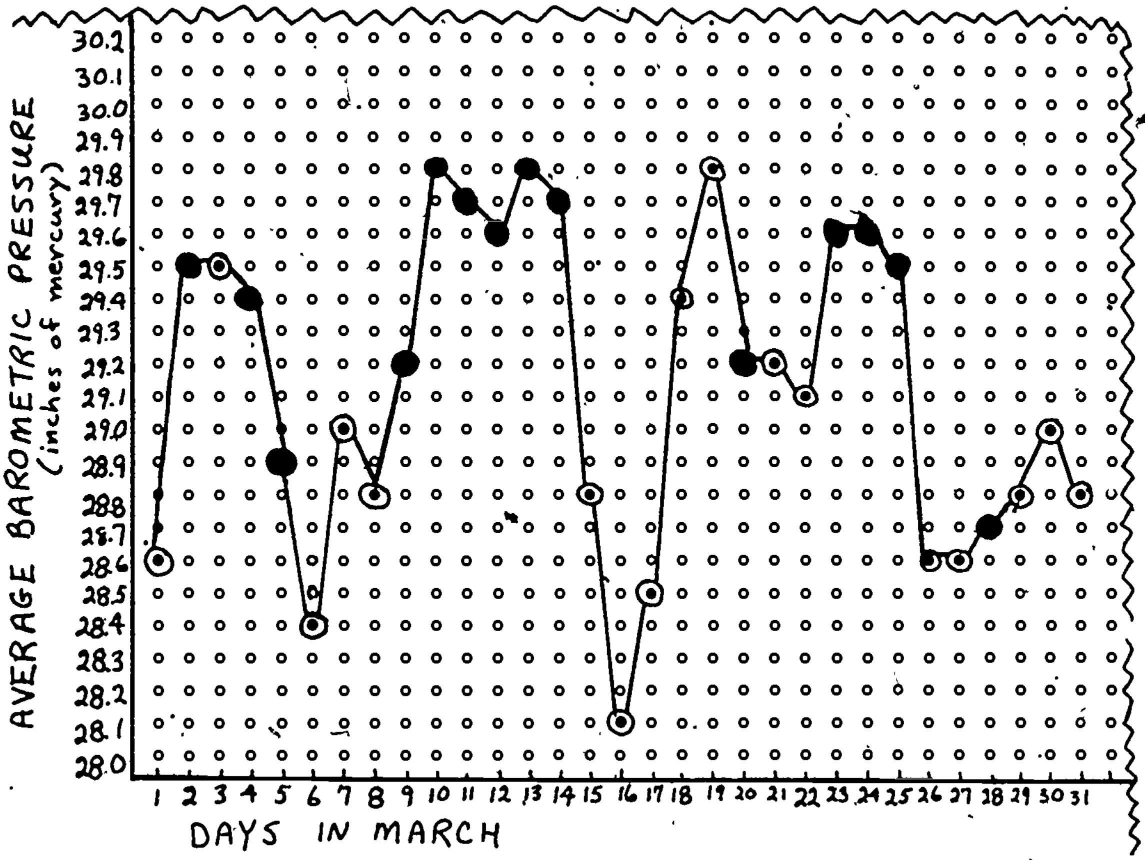
And to show the fourth day, you hang a colored peg at 29.4 above Day 4.

You keep doing this until the end of the month.

You can connect the pegs with a piece of yarn or string. That might help you see the graph better.



Here is the graph for the whole month of March.



You want to know if it always rains when the pressure falls. The graph shows that sometimes the pressure rose, sometimes it stayed the same, and sometimes it fell.

When did the pressure fall? Look for places where the pegs are lower than they were the day before. The pressure fell on 14 days: Days 4, 5, 6, 8, 11, 12, 14, 15, 16, 20, 22, 25, 26, and 31.

How many of those 14 days were rainy? Look for the colored pegs. On seven of those days it was rainy: Days 4, 5, 11, 12, 14, 20, and 25.

Seven out of 14 is one-half. It didn't always rain when the pressure fell.

You might want to collect more data to see whether you get different results at other times.

THINGS TO KEEP IN MIND ABOUT BAR GRAPHS

IS A BAR GRAPH THE BEST GRAPH TO SHOW YOUR DATA AND ANSWER YOUR QUESTIONS?

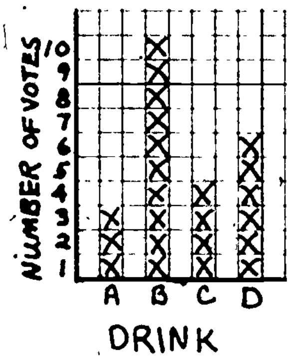
- Is one part of your data SEPARATE ITEMS?
- Is another part of your data NUMBER COUNTS or MEASUREMENTS?

If your answer to both questions is "yes", a bar graph is probably a good graph to make.

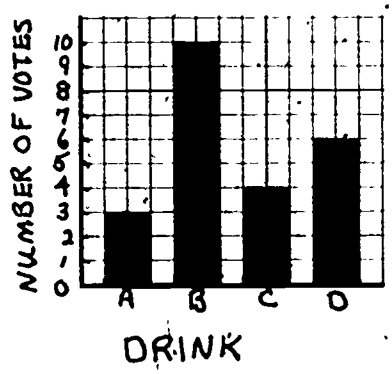
If you answered "no" to either question, you might want to make another kind of graph. The booklets "How To" Choose Which Graph to Make for One Set of Data and "How To" Use Graphs to Compare Two Sets of Data might help you find a better graph for your data.

WHAT KIND OF BAR GRAPH SHOULD YOU MAKE?

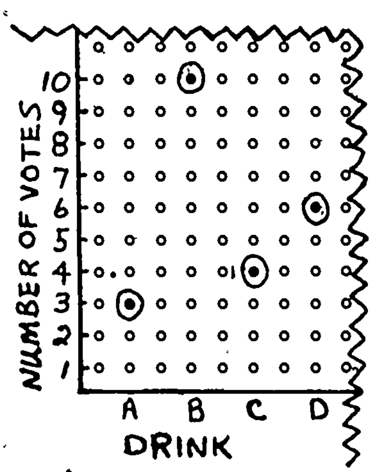
Do you want to make your bar graph at the same time that you collect your data? If so, make a BAR GRAPH TALLY.



Do you want to make your bar graph after you have made a data chart? If so, make a REGULAR BAR GRAPH.



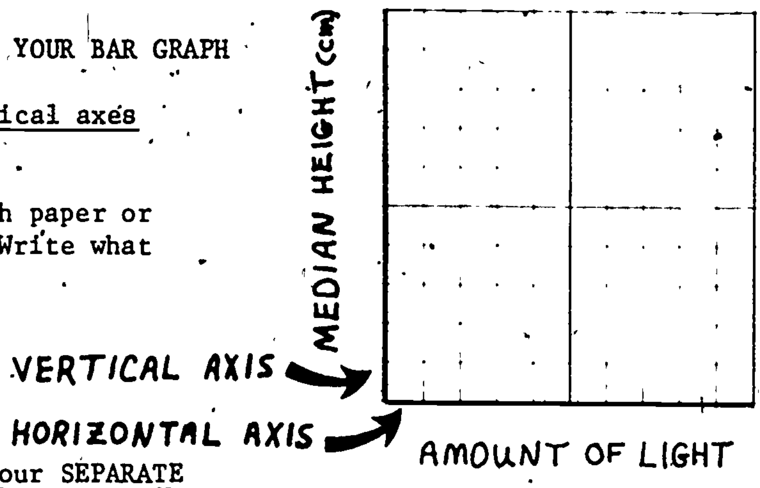
Do you want to make a large classroom bar graph in an easy way? If so, you can make a PEGBOARD BAR GRAPH. It can be made at the same time you collect your data or after you have made a data chart.



THINGS TO REMEMBER WHEN YOU DRAW YOUR BAR GRAPH

1. Draw the horizontal and vertical axes carefully.

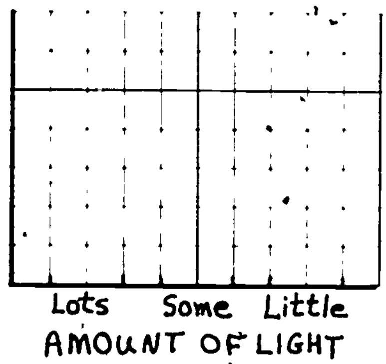
   Follow the lines of the graph paper or the holes of the pegboard. Write what each of the axes stands for.



2. The horizontal axis is for your SEPARATE ITEMS.

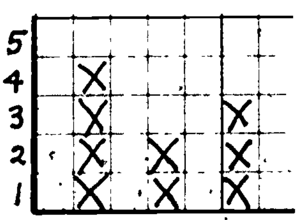
   Write their names beside the spaces, not on the lines.

   If the order of the items makes a difference, arrange them in an order that makes sense for your problem.



3. The vertical axis is for your NUMBERS.

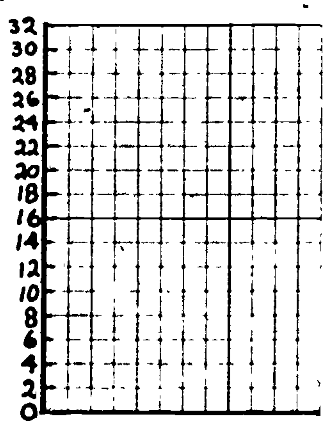
   If your graph will have Xs, write the numbers beside the spaces.



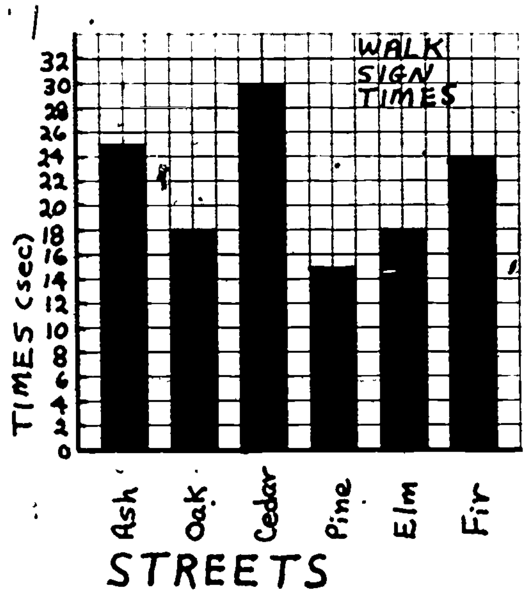
If your graph will have bars, write the numbers beside the lines. Put tick marks on the lines that are opposite the numbers.

4. Make sure that all the numbers in your data fit the spaces along the vertical axis.

   If you don't have enough room, you can make the spaces stand for more than one number.



5. Make the tops of the columns straight so that they line up with the numbers on the vertical axis.



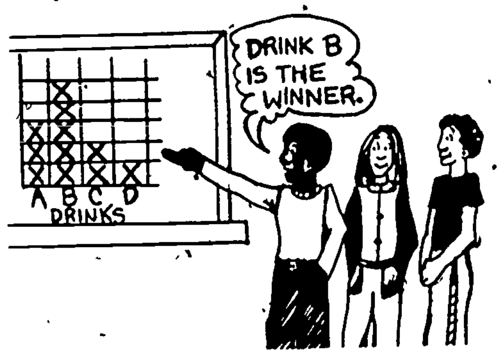
6. Make the columns all the same width.

You can leave spaces between the columns in order to see the bars more clearly.

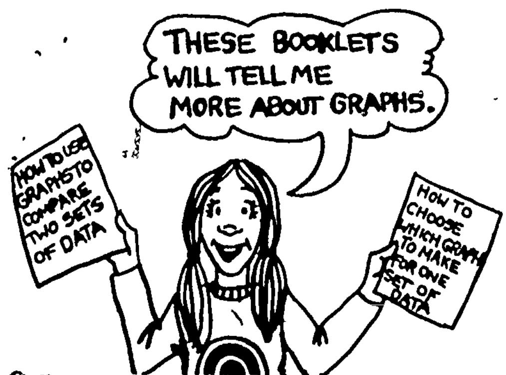
7. Make up a title for your graph so that others will understand what it shows.

THINGS TO THINK ABOUT AFTER YOU HAVE MADE YOUR GRAPH

- Figure out what the graph tells you. Were your questions answered? Can others read the data on the graph easily?



- Is there a better way to show your data? Perhaps you will want to reorganize your data and make another kind of graph, such as a line chart or a bar graph histogram?



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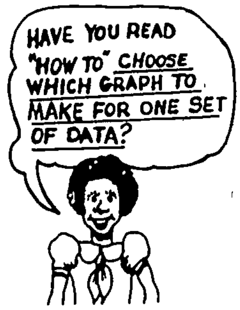
"HOW TO"

MAKE A HISTOGRAM

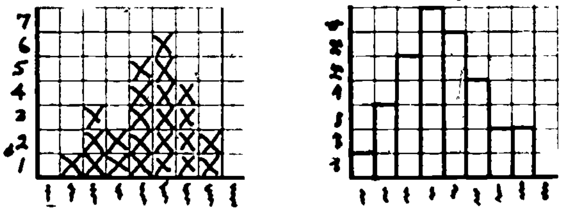
Do you have lots of measurements or number counts from many different people? Perhaps you have measured eye-level heights to find out the best heights to hang posters so that most children can see them easily. Or maybe you have counted the number of right answers each child in your class got on a test.



Do you wonder how your measurements or number counts will help you answer your questions? You can make a HISTOGRAM.

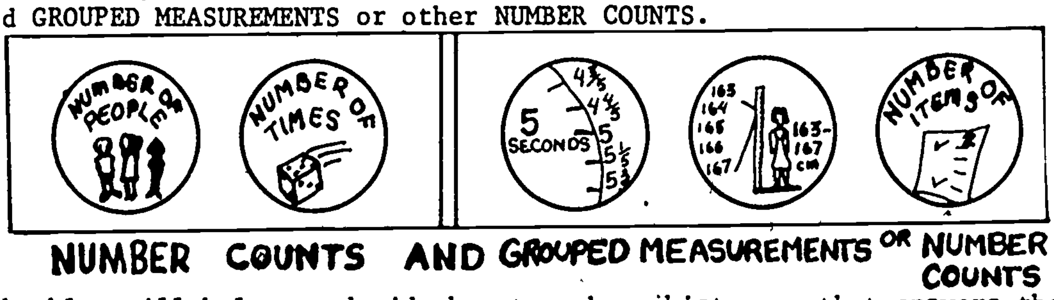
WHAT IS A HISTOGRAM?

A histogram is a kind of bar graph. It is a picture of the number of times the same measurement or number count comes up or the same thing happens. Each column in a histogram stands for a group of measurements or number counts. The height of the bar tells how many times those measurements or number counts were listed in the data chart. A histogram will help you see patterns in the measurements you have made.



WHEN SHOULD YOU MAKE A HISTOGRAM?

Make a histogram when your measurements or number counts are in groups or when it helps to put them into groups. Then your data are NUMBER COUNTS and GROUPED MEASUREMENTS or other NUMBER COUNTS.



This booklet will help you decide how to make a histogram that answers the questions you have.

WHAT'S INSIDE

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HOW MANY SCORED HIGH ON THE TEST?

Suppose you want to know how all the students in your class scored on a test. The test has eight questions on it.

You count the number of right answers each student made. Here are the numbers for 24 students.

Number of Right Answers

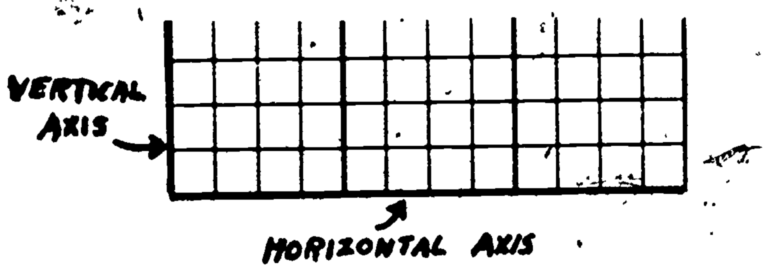
5	2	7	3
6	6	7	4
3	6	4	5
7	4	5	4
6	8	5	6
5	6	6	7

You have lots of numbers. What is an easy way to tell how many students scored high on the test and how many scored low on the test? You can count the number of students who got 0 right, 1 right, and so on. You can tally on a data chart like this.

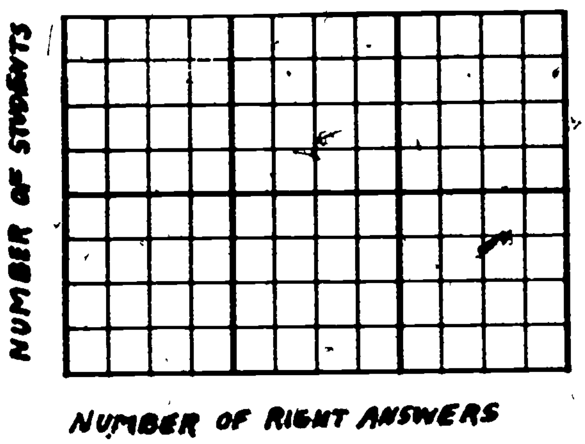
SCORES ON TEST DEC. 3

NUMBER OF RIGHT ANSWERS	NUMBER OF STUDENTS
0	
1	
2	/
3	//
4	////
5	~~////~~
6	~~////~~ //
7	////
8	/

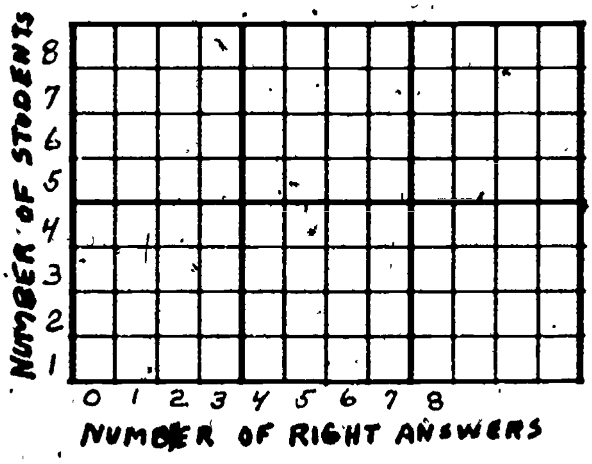
The tally sheet looks like a histogram turned sideways. You can make a real histogram. It will show the data better. Here is how to make one. First, draw two lines on graph paper. One line goes across the bottom of the paper. The other line goes along the left side of the paper. The bottom line is called the <u>horizontal axis</u>. The side line is called the <u>vertical axis</u>.



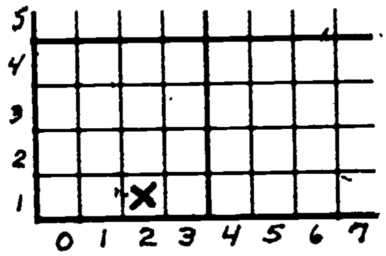
The horizontal axis is for the number of right answers. The vertical axis is for the number of students. Label the two lines. Leave room to put numbers near the lines.



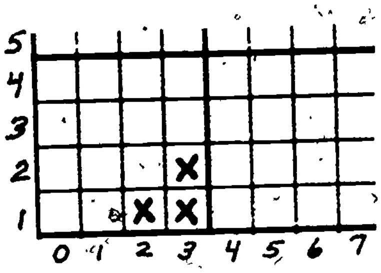
Next, write the numbers 0 to 8 in the spaces below the horizontal axis. These numbers are for the number of right answers. Write numbers from 1 to 7 in the spaces along the vertical axis. These numbers are for the number of students.



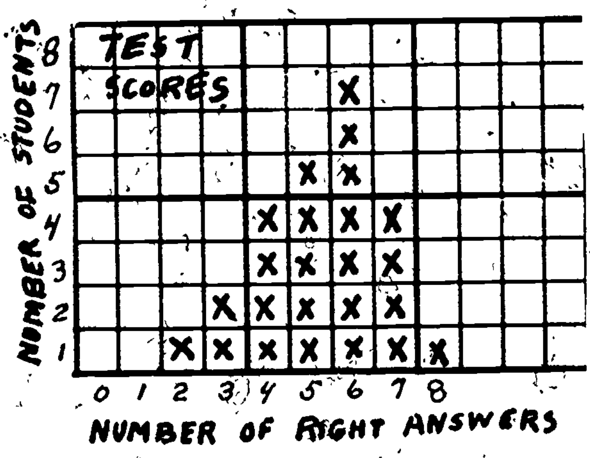
Now you are ready to put the data on the histogram. Look at your data chart. One student got 2 answers right. Put an X in the column marked 2 on the horizontal axis.



Two students got 3 answers right. Put two Xs in the column marked 3 on the horizontal axis.



Keep filling in Xs until all the data is on the histogram. You have scores from 24 students. There should be 24 Xs on the histogram. Now put a title on the graph. The finished histogram looks like this.



What does the histogram tell you? The tallest column is marked 6. More students got 6 answers right than any other number. You can also see from the pattern of Xs that most of the students got more than 4 of the 8 answers right. One student got 2 right and one student got 8 right.

WHAT IS THE BEST HEIGHT TO HANG POSTERS?

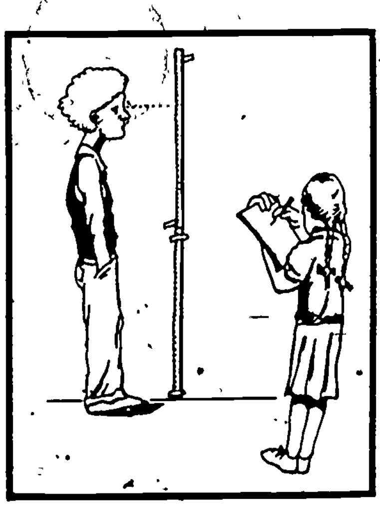
In the first example you made a histogram from data on NUMBER COUNTS and NUMBER COUNTS. Each column showed one number. In this example you make a histogram from NUMBER COUNTS and MEASUREMENTS. You put the measurements into groups before you make the histogram.

Suppose that you are making posters to advertise different things to buy and sell to students in your grade. You will hang the posters in your classroom, in the other classrooms, and in the hallway near your room. At what height should you hang the posters so that others in your grade will be able to read them easily? You want to hang the posters so that not too many students will have to look down at the posters and not too many students will have to look up at them.

First you need to collect data. You measure the height of each student in your class. Because you will be hanging the posters at eye level, you measure each student from his or her eye level to the floor. You read "How To" Round Off Data as You Measure and decide to round off each measurement to the nearest centimeter. Here are the measurements you have made for 31 students.

EYE-LEVEL HEIGHTS (cm)

137	140	133	146	140
145	126	141	142	134
133	139	134	150	138
138	146	137	147	140
151	140	131	141	135
151	141	131	150	142
				144



You have lots of numbers. What should you do with them? It will help to put the measurements into groups and then make a histogram. That way, you can see whether there is a pattern to the measurements.

What grouping should you choose for your histogram? That depends on the question you want to answer. For this problem, you can put your measurements into groups of 5 centimeters. A difference of 5 centimeters in height is big enough to make some difference in how well someone can read a poster, but not so big that you can't see the pattern in the measurements.

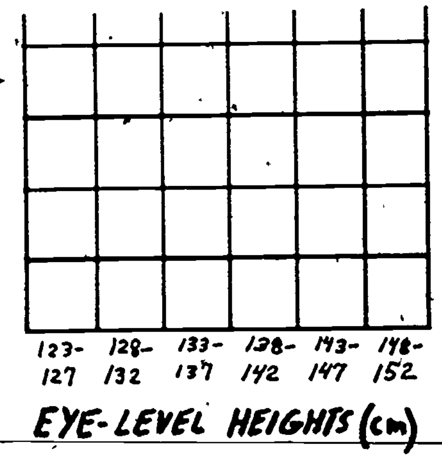
ERIC

Which grouping of 5 centimeters should you choose? You have to consider two things. First, the shortest height you measured is 126 centimeters. The tallest height is 151 centimeters. So you know that your groupings will have to include both 126 centimeters and 151 centimeters. Second, when possible the middle of each grouping should be a number ending in 5 or 0. These are common numbers which can be used to tell about the whole grouping. The two things are taken care of with groups of:

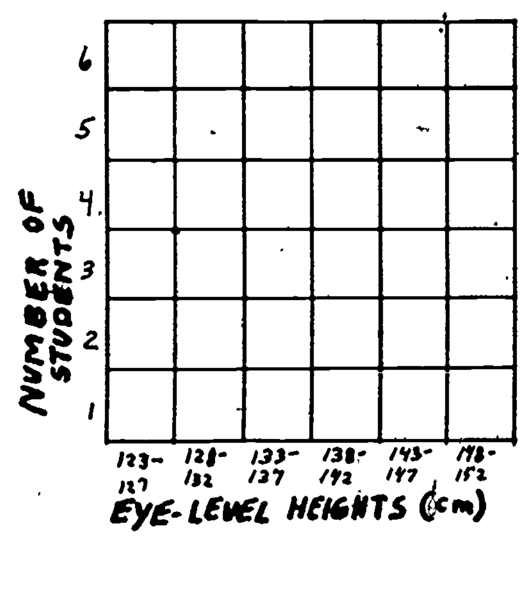
123	128	133	138	143	148
124	129	134	139	144	149
125	130	135	140	145	150
126	131	136	141	146	151
127	132	137	142	147	152
123–127 cm	128–132 cm	133–137 cm	138–142 cm	143–147 cm	148–152 cm

Notice that the groupings are equal; each has 5 measurements in it. The groupings are arranged in order from smallest to largest. The middle of each grouping is a number ending in 5 or 0.

Now that you have made your groupings, draw two lines on graph paper. The horizontal axis will be for the different groupings of heights you measured in centimeters. Label that line EYE-LEVEL HEIGHTS (cm). These are the measurements you put into groups of 5 centimeters. Write the numbers in the spaces along the bottom line.



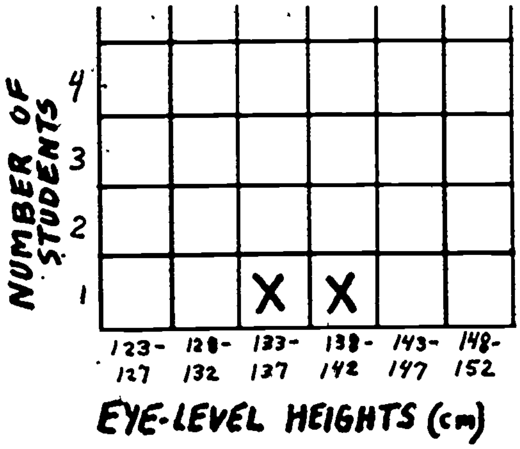
The vertical axis is for the number counts. Label that line NUMBER OF STUDENTS. You can use either Xs or bars in a histogram. (Usually, we use Xs when we can count by ones. We use bars when we count by more than one.) In this booklet we will use Xs. Write numbers beginning with 1 in the spaces beside the vertical axis.



Now the graph is ready to be filled in. You can tally your data right on the histogram. The first number is 137. Put an X in the column 133-137. The next number is 140. Put an X in the column 138-142.

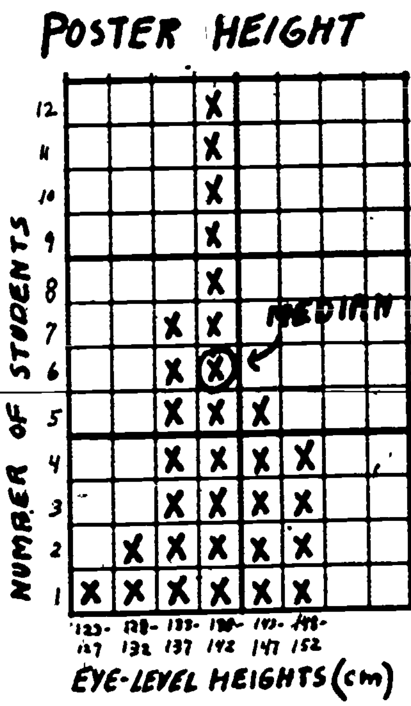
EYE-LEVEL HEIGHTS (cm)

137	140	133	146	140
145	126	141	142	134
133	139	134	150	138
138	146	137	147	140
151	140	131	141	135
151	141	131	150	142
				144



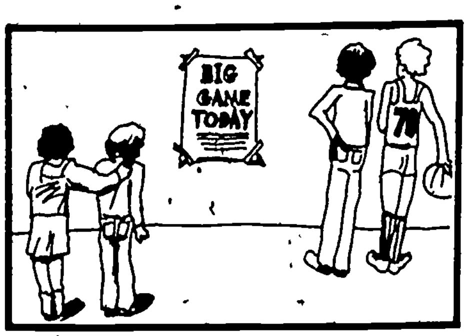
Keep filling in Xs until you have shown all the data. Each X stands for one student. You measured 31 students; so you should have 31 Xs. Check your graph to make sure that you do. Finally, put a title on your graph.

The finished graph looks like this. What does it tell you? You can see that more of the heights fall in the middle grouping than in any other grouping. The other heights are pretty evenly divided on either side of ~~the~~ column.



To make sure that the heights are evenly divided on either side of the middle grouping, you can find the median height. That is the number that falls exactly in the middle of the data. (If you need help, read the booklet "How To" Find the Median.) The median measurement is in the 138 cm to 142 cm grouping. You can think about the middle group as being about 140 centimeters, because 140 is right in the middle of 138 and 142.

Now you know that you can hang each poster so that its center is 140 centimeters from the floor. That height will be good for most people you measured. The posters may be a bit too high for some students and a bit too low for others. But 140 centimeters is probably as fair a height as you can find for all the students in your grade.

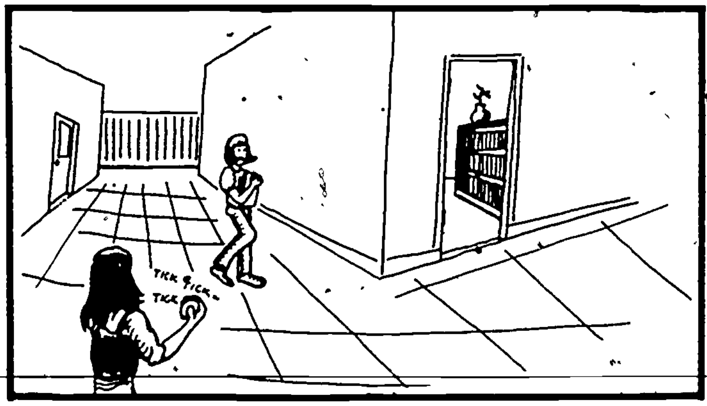


HOW LONG DOES IT TAKE TO GET TO THE LIBRARY?

In the last example you used a histogram to find the median height. You can also use a histogram to find out what measurements or number counts most people had. You might want to find out what scores on a test most children had as in the first story in this booklet. Or maybe you want to find out the time it took most children to find a certain place in the school. That is what this example is about.

Suppose that many younger children in your school get confused trying to find the school library. Your class wants to make signs to help them find their way. But before you do, you would like to see how long it takes some first graders to find the library on their own.

Let's say that there are 8 first grade classes. It would be too much work to time all the children; so you pick a sample of 25 students. (If you don't know how to pick a sample, read the booklet "How To" Choose a Sample.) Then you make a starting point in the hallway near the first grade classrooms. With a stopwatch, you time each child as he or she tries to find the library from the starting point.

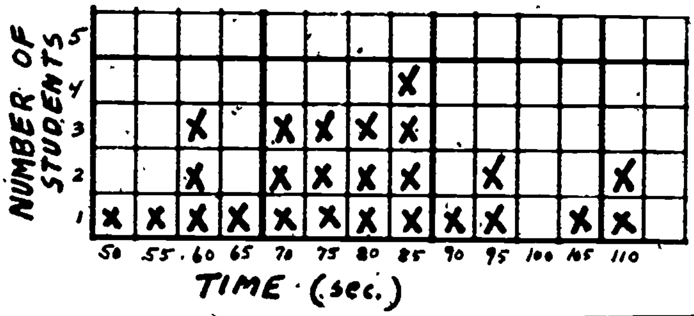


You decide to round off the measurements to the nearest five seconds because that is about as accurate as your measurement can be. Here is a list of the times.

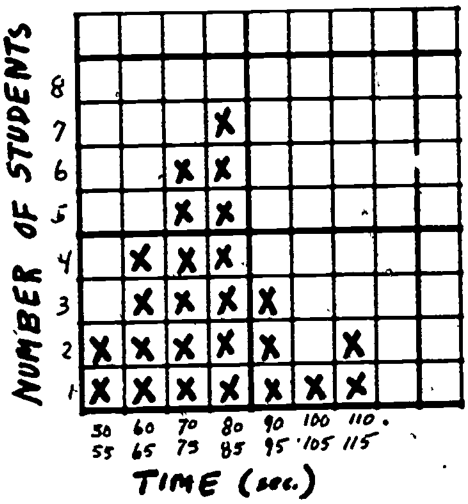
NUMBER OF SECONDS TO FIND THE LIBRARY
(rounded off to nearest 5 seconds)

60, 75, 80, 100, 50, 95, 70, 75, 110, 60, 55, 75, 80, 85
65, 110, 95, 85, 85, 60, 70, 70, 85, 80, 90

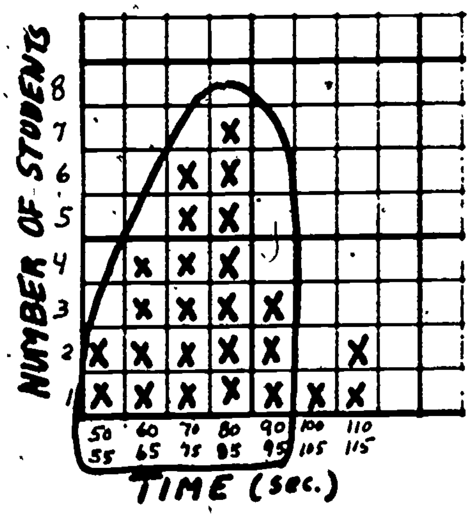
Now how should you group your measurements? That depends on your purpose for making the histogram. You want to find out the time it takes most children to find the library before you hang signs. You will then want to compare those data with the time it takes most children to find the library after the signs are up. So you want to have fairly small groups. You might decide to have each group include times within 5 seconds of one another. Your data are already in 5-second groups because of the way you rounded off. You first make a histogram with each rounded-off measurement in one column. Your histogram looks like this.



You decide that the graph looks too flat. It is hard to see a clear pattern. You decide to put two measurements in each column. Your next histogram looks like this.



This histogram lets you see the pattern of numbers in a way that would be hard to see from your list. You can follow the top X of each column to the side number. That will tell you how many children there were in each time period. You can see, for example, that 7 students took 80 or 85 seconds to find the library. You can tell from the graph that nearly all the children, 22 out of 25, took 95 seconds or less to find the library.



HOW MANY OF EACH SIZE BELT SHOULD WE MAKE?

When you are making things to fit a lot of people, you will probably need to figure out ahead of time what sizes are needed and how many of each size to make. This may happen if you are making aprons for the Design Lab, or tables for your classroom, or belts or slippers to sell at a school fair.

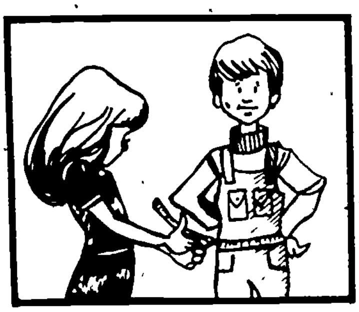
A histogram can help you see the pattern of measurements you have made. This example shows you how to use a histogram to answer your questions about sizes.

Your class may want to make belts to sell to other students in the school. How do you decide what the sizes should be? And how many different sizes should you make?

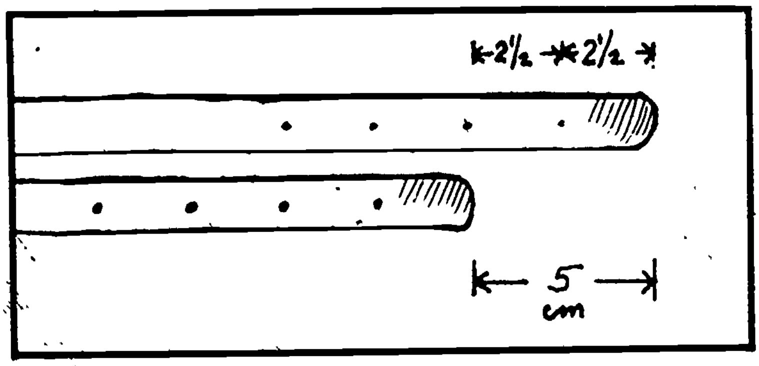
First, you choose a sample of 30 children in the school. You measure their waists and round off the measurements to the nearest centimeter. Here is a list of the data you collected.

WAIST SIZES (nearest centimeter)

66, 61, 65, 63, 65, 62, 71, 70, 67, 65, 74, 70
65, 75, 68, 61, 71, 65, 66, 60, 66, 71, 70, 64
76, 72, 70, 66, 72, 60



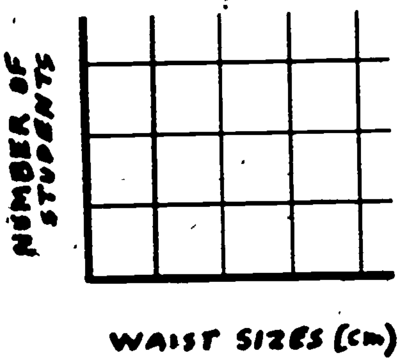
You don't want to make a special belt size for each child. You decide to put ~~your data into groups. But how big should the groups be? To find out you~~ measure the distance between two holes in the belt. You find that the distance is about 2½ centimeters. You decide to put four holes in each belt. You also decide to have two holes in one size overlap two holes in the next size. Then you figure that the difference in lengths will be 5 centimeters.



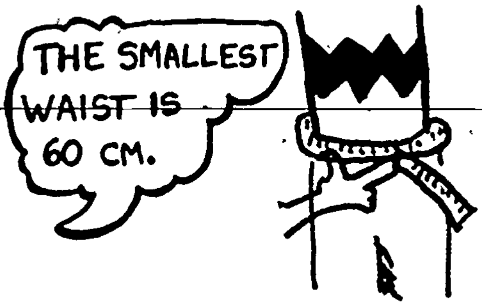
You decide to put your data into 5-centimeter groups. That means that you will have sizes for children whose waists are about 60 centimeters, 65 centimeters, 70 centimeters, and so on.

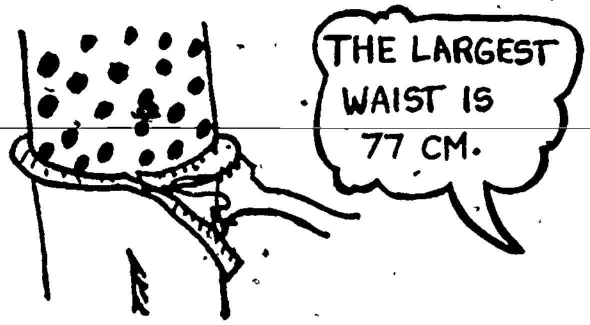
You still need to decide how many sizes to make and about how many belts to make in each size. You need to see the pattern of the measurements; so you will make a histogram.

Set up the graph as usual, with the horizontal axis for the grouped measurements (waist sizes) and the vertical axis for the number counts. Be sure to label the lines.

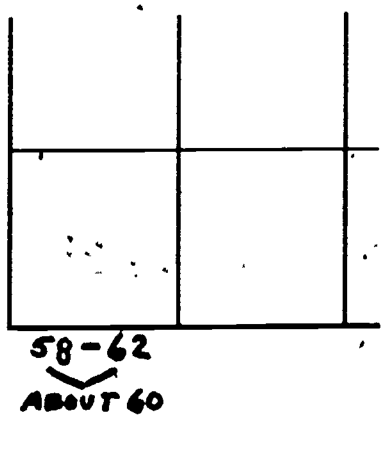


You have already decided to put the measurements into groupings of 5 centimeters, but which number should you start with? You can see from the list that the smallest waist size is 60 centimeters and the largest is 77 centimeters. Your groupings will have to include both 60 centimeters and 77 centimeters.

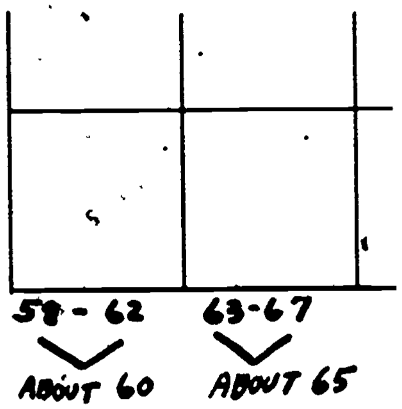




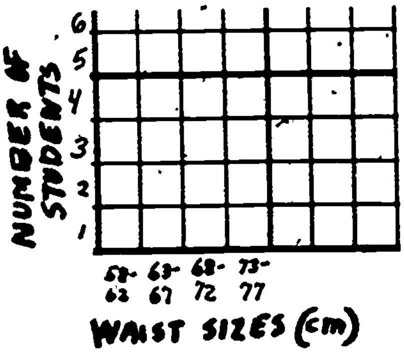
Make the first grouping 58-62 centimeters. It will take care of five measurements: 58, 59, 60, 61, and 62 centimeters. The middle number is 60. This grouping will be for the children whose waists are about 60 cm.



Then the next grouping will go from 63 to 67 centimeters. That will take care of the children whose waists are <u>about 65 cm</u>.



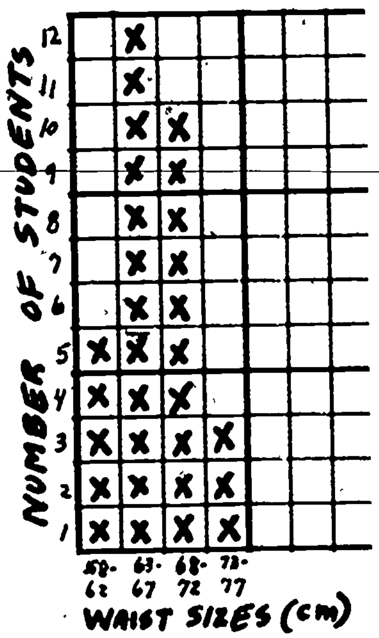
Keep doing this until you have all the groupings of 5 that you need. Fill in the side numbers. Then you are ready to draw the histogram.



For each measurement in your list of data, make an X in the correct column. The finished histogram looks like this:

WAIST SIZES (cm)

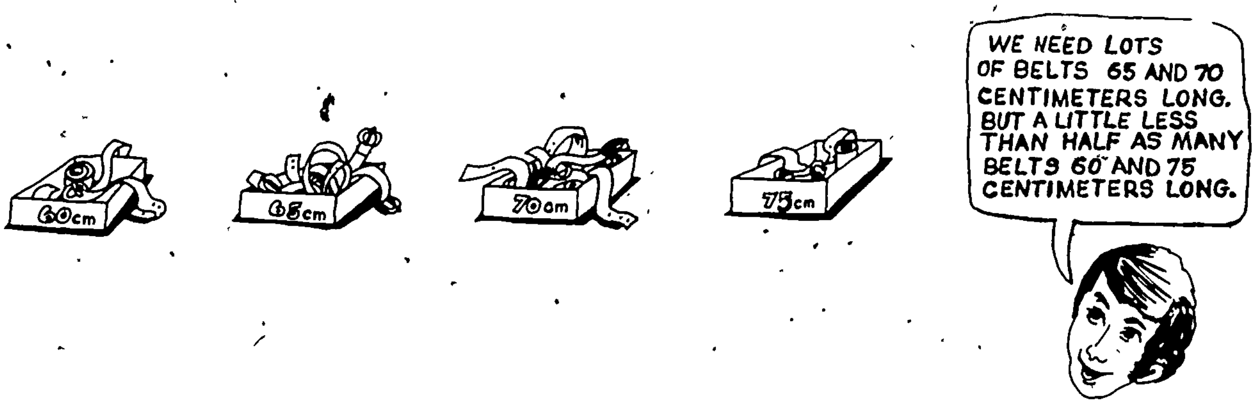
66, 61, 65, 63, 65, 62, 71, 70, 67, 65, 74, 70, 65, 75, 68, 61, 71, 65, 66, 60, 66, 71, 70, 64, 76, 72, 70, 66, 72, 60



There are four columns. That means that you should make at least four sizes of belts. Your groupings included waist sizes of a sample of students. A few students not in the sample might have waist sizes smaller or larger than those measured. For these students you might make belts to order rather than have very small or very large belts on hand.

ERIC

The two middle columns in the histogram are the highest. That means that you should make lots of belts to fit people whose waists are about 65 centimeters and about 70 centimeters. The columns on the ends are much shorter. You don't need to make as many belts in those sizes.



THINGS TO KEEP IN MIND ABOUT HISTOGRAMS

IS A HISTOGRAM THE BEST GRAPH TO SHOW YOUR DATA AND ANSWER YOUR QUESTIONS?

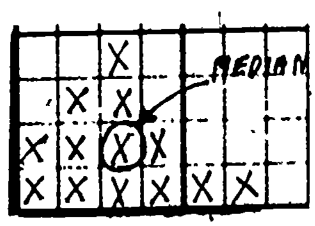
- Is one part of your data NUMBER COUNTS?
- Is the other part of your data NUMBER COUNTS or MEASUREMENTS?
- Do you have 15 or more measurements?

If your answer to all three questions is "yes," a histogram is probably a good graph to make.

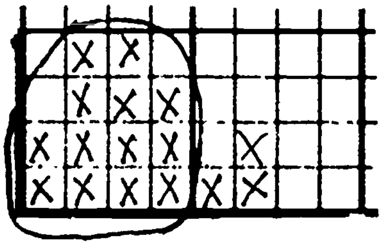
If you answered "no" to any question, you might want to make another kind of graph. The booklets "How To" Choose Which Graph to Make for One Set of Data and "How To" Use Graphs to Compare Two Sets of Data might help you find a better graph for your data.

WHAT KINDS OF QUESTIONS CAN A HISTOGRAM HELP YOU ANSWER?

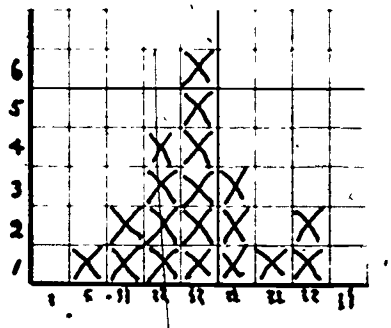
- What is the best height to put posters, chalkboards, or a pencil sharpener?



- How many seconds does it take most first-graders to find the library? Most children to cross the street?

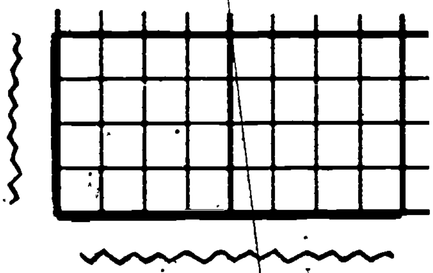


- How many of each size belts, or caps or wristbands should we make? How many of each size swings or monkey bars should we buy?

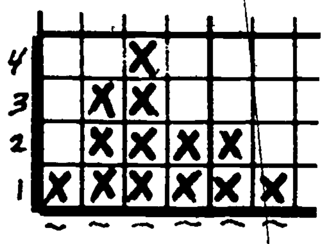


THINGS TO REMEMBER WHEN YOU DRAW YOUR HISTOGRAM

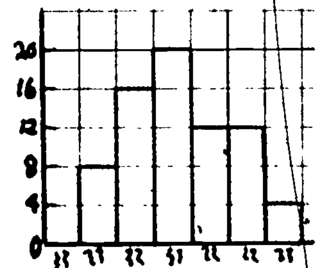
1. Draw the axes carefully. Follow the lines of the graph paper. Write what each of the axes stands for.



2. <u>The vertical axes is for the number counts.</u> A histogram can have either Xs or bars. If your graph will have Xs, write the numbers beside the spaces.



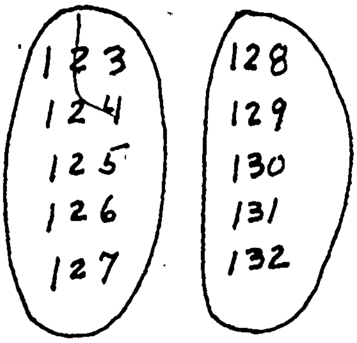
If you don't have enough spaces on the side line for all your Xs, you can make each space stand for more than one number. Then you can make bars instead of Xs. When you have bars, write the number beside the lines.



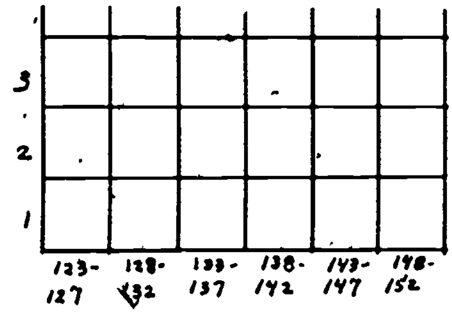
3. <u>The horizontal axis is for your grouped measurements or number counts.</u>

Decide how big your grouping should be. Does the question you are asking tell you how big the groups should be?

Decide where each group should begin and end. If they are large groups try to have a number ending in 5 or 0 in the middle of each group. Make sure there is a place to tally every piece of data from the smallest to largest.



Write the groups in order from smallest to largest under the spaces.

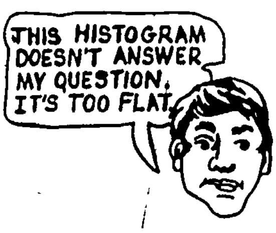


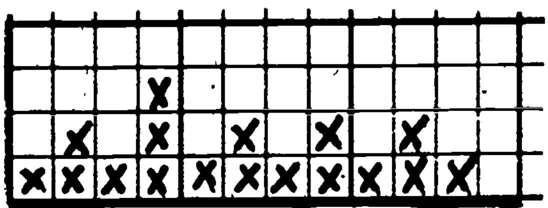
4. Put your data on the graph.

5. Make up a title for your graph so that others will understand what it shows.

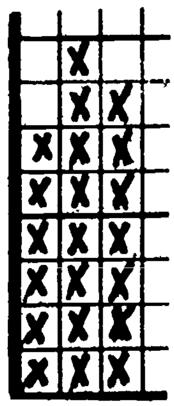
THINGS TO THINK ABOUT AFTER YOU HAVE MADE YOUR HISTOGRAM

- Figure out what the graph tells you. Were your questions answered? Can others read the data on the graph easily? What patterns do you see?
- Is there a better way to show your data? If your histogram is too flat and wide, you may want to collect more data or make larger groupings.





If your histogram is too tall and narrow, you may want to group your measurements another way.



"HOW TO"

MAKE A LINE GRAPH

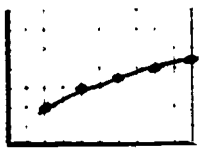
DO YOU WANT TO COMPARE A SERIES OF MEASUREMENTS COLLECTED FOR DIFFERENT TIMES, WEIGHTS, OR DISTANCES?

You may want to keep track of how the temperature changes during the day. You may want to find out how your plant grows over a period of several weeks. You may want to find out how fast a model car rolls when it starts at different heights on a hill. You may want to find out how much an elastic stretches for different weights.

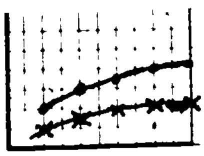
If you want to know how several measurements compare with one another, you can make a LINE GRAPH.

WHAT IS A LINE GRAPH?

A line graph is a picture of a series of measurements. It can tell you how something is growing or how it is changing. A line graph is special because it helps you find extra information that you didn't know about when you started.

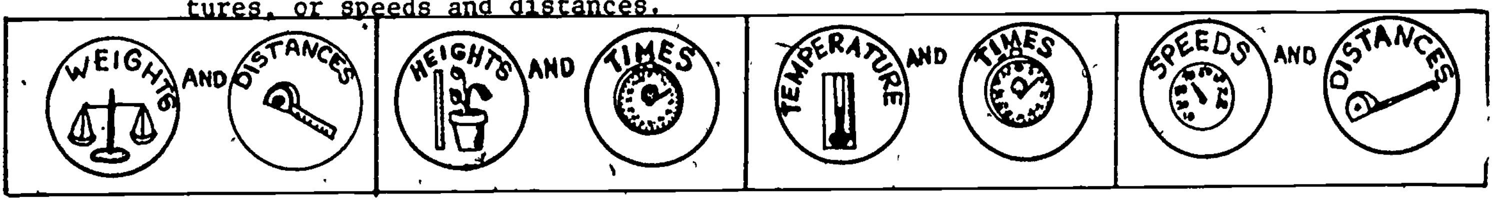


Making two line graphs can help you compare two sets of data so that you can get even more information.



WHEN SHOULD YOU MAKE A LINE GRAPH?

You can make a line graph when both parts of your data are measurements. The measurements might be times and weights or heights, times and temperatures, or speeds and distances.



This booklet will show you how to make line graphs that will answer the questions you have.

WHAT'S INSIDE | PAGE

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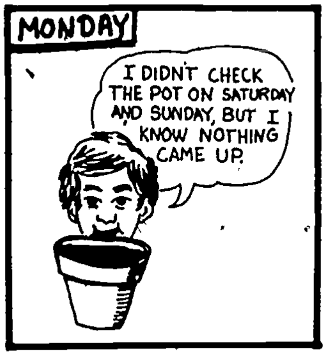
WATCHING A PLANT GROW

Suppose that students in your class are planning to grow plants to sell at a school fair. You will grow the plants from seeds. Then, when the plants are 8 centimeters tall, you will put them into larger pots and sell them. You wonder how long before the fair you should plant the seeds so that they will be ready for repotting at the right time.

Let's say that you plant a seed on Thursday. When you come back to school on Monday, you check the pot. It looks the same as it did on Thursday and Friday. You check again on Tuesday. Nothing seems to have happened. On Wednesday, the sixth day since you planted the seed, you see a tiny green stem and the beginnings of two leaves. Your plant has sprouted. It is two centimeters high.

You set up a data chart. The day you planted the seed can be called Day 0. Because the seed didn't come up right away, the plant's height was 0 centimeters. It stayed 0 centimeters for Days 1, 2, 3, 4, and 5. On the morning of Day 6, the plant was 2 centimeters high. The first six lines on the chart are not very interesting, but the last line has given you some hope.

MY PLANT'S GROWTH	April 7
Days Since Planting	Height (cm)
0 (Thursday)	0
1 (Friday)	0
2 (Saturday)	-
3 (Sunday)	-
4 (Monday	0
5 (Tuesday)	0
6 (Wednesday)	2



The plant keeps growing. You continue to check the height at the same time each day, measuring to the nearest half centimeter.

Here is the bottom part of the data chart.

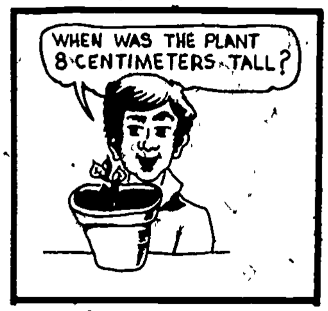
6 (Wednesday)	2
7 (Thursday)	2.5
8 (Friday)	3
9 (Saturday)	-
10 (Sunday)	-
11 (Monday)	4
12 (Tuesday)	4.5
13 (Wednesday)	4.5
14 (Thursday)	6
15 (Friday)	7

By Friday, the 15th day, the plant is 7 centimeters tall. "The plant seems to be growing fast," you think to yourself. "In another couple of days it will be ready for repotting."

You measure the plant the first thing Monday morning. It is 9.5 centimeters high. "My plant shot up 2.5 centimeters over the weekend," you say. "I had better pot it right away, since it's already taller than 8 centimeters."

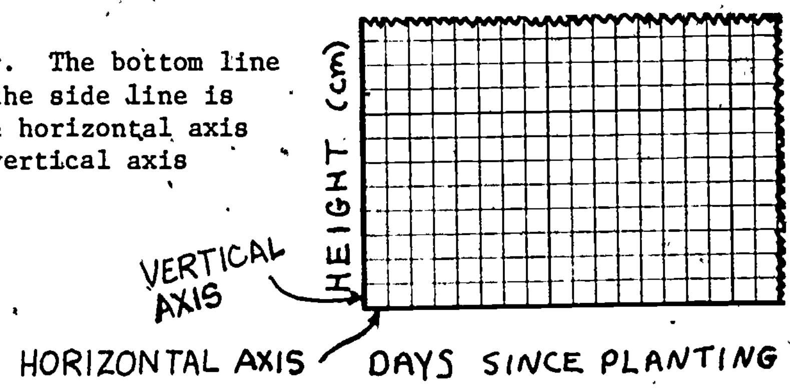
As you repot it, you wonder on which day of the weekend the plant was really 8 centimeters tall.

Days Since Planting	Height (cm)
14 (Thursday)	6
15 (Friday)	7
16 (Saturday)	?
17 (Sunday)	?
18 (Monday)	9.5

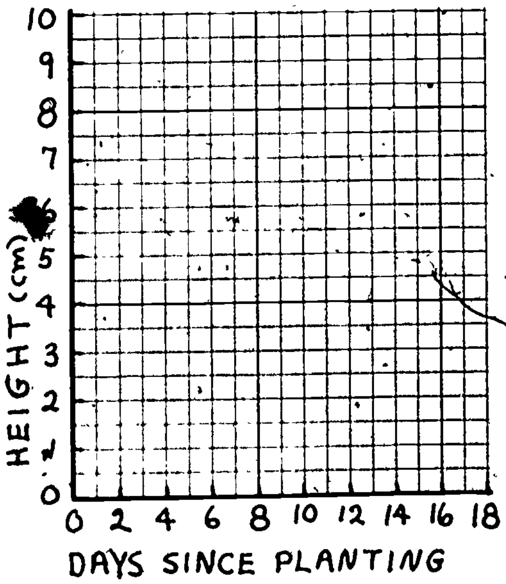


You can make a graph to find out. Both parts of your data are <u>measurements</u>. One measurement is time: the number of days since the seed was planted. The other measurement is height: the number of centimeters tall your plant is. So you know that you can make a LINE GRAPH. Here is how to do it for your data.

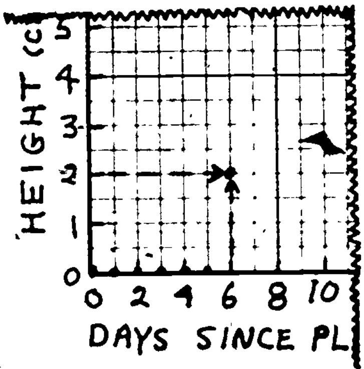
Draw two lines on graph paper. The bottom line is the HORIZONTAL AXIS, and the side line is the VERTICAL AXIS. Label the horizontal axis DAYS SINCE PLANTING and the vertical axis HEIGHT (cm).



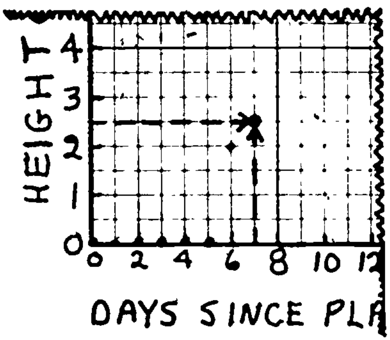
Write numbers for the days and for the height. <u>In a line graph, you should write the numbers beside the lines of the graph, not in the spaces.</u> The tick marks will show which lines the numbers are for.



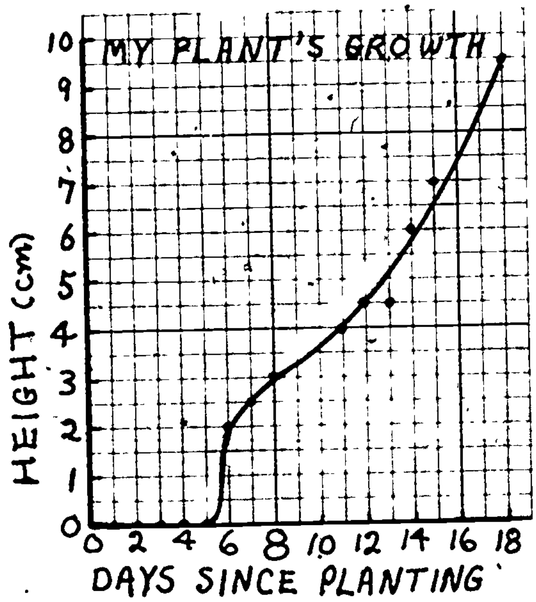
Now you can start marking the points on the graph. The data for the first six days are nearly the same. On Days 0, 1, 2, 3, 4, and 5 the seed didn't come up at all. The height of the plant was 0. Draw dots at the 0 marks for those days. On Day 6, the height was 2 centimeters. To mark that point, go over to Day 6 and up to the 2-centimeter marking. Make a large dot at the point where those lines meet.



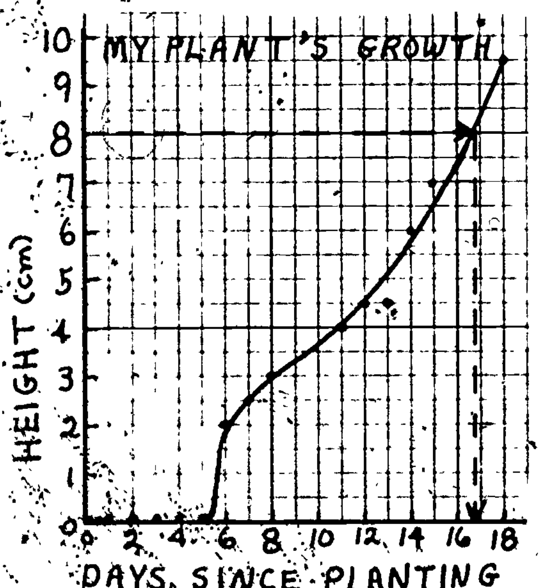
On Day 7, the plant was 2.5 centimeters tall. Go over to Day 7 and up to 2.5 centimeters. Draw a dot halfway between the marking for 2 centimeters and 3 centimeters.



Then fill in the rest of the points. When you finish plotting the points, draw a smooth line that goes through all or most of the points. The line doesn't have to go through every point because there are always errors in measurement. Also, the line shouldn't have any sharp bends in it. Here is how the graph looks for all the days up to Day 18.



The line you drew is a picture of the growth of your plant. It should tell you when the plant grew quickly and when it didn't grow at all. But how can you tell on which day the plant was 8 centimeters tall?



Find 8 centimeters on the HEIGHT line. Then run your finger along that line until you hit the line of the graph. From there, run your finger down to the DAYS SINCE PLANTING line. You have ended up between Days 16 and 17. That means that your plant probably reached 8 centimeters late on the 16th day after you planted the seed. The 16th day was Saturday.

You have just figured out a piece of data you haven't measured by <u>looking between</u> the points of the data that you have measured. This is called <u>interpolation</u>. In this example, you didn't know on which day your plant was 8 centimeters tall. But you could find out by looking at the line graph you plotted. Points on the graph showed when the plant was 7 centimeters tall and when it was 9.5 centimeters tall. Then you used the line on the graph to find out possible measurements <u>between</u> those points.

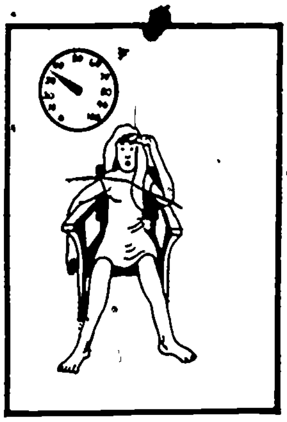
WHEN WAS IT HOTTEST?

The last example showed you how to use a line graph to interpolate a possible measurement smaller than the largest measurement. This example shows you how to interpolate data to find the largest measurement.

Suppose that your part of the country is having a heat wave. It has been hot for many days in a row and some weather records have been broken. One day, you decide to keep track of the temperature every two hours, starting at 8:00 in the morning and ending at 10:00 at night.

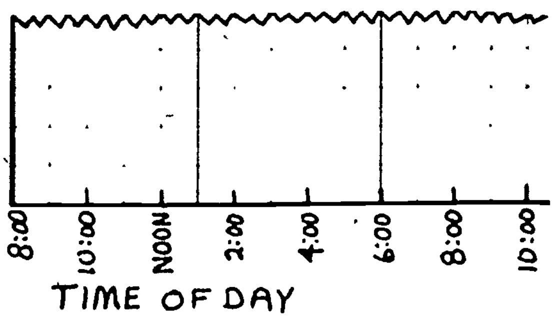
At the end of the day your data chart looks like this:

TODAY'S TEMPERATURE	July 31
Time	Temperature (Degrees Celsius)
8:00 A.M.	26
10:00 A.M.	29
Noon	32
2:00 P.M.	34
4:00 P.M.	34
6:00 P.M.	33
8:00 P.M.	30
10:00 P.M.	29

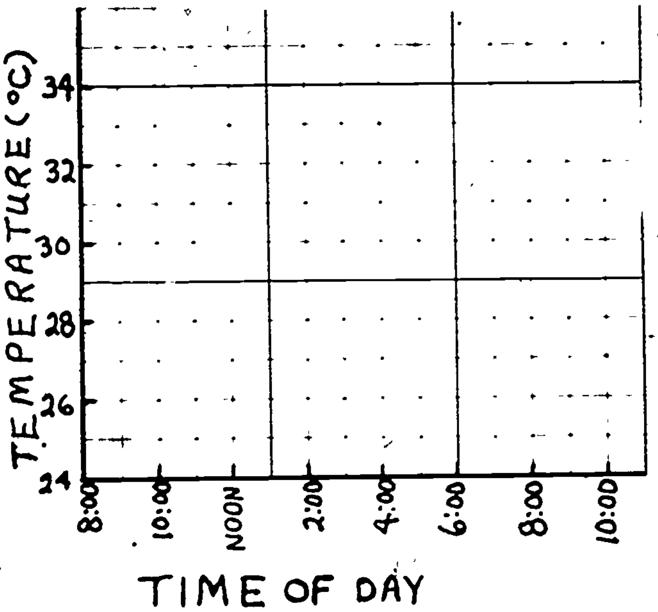


You decide to make a line graph to show how the temperature changed throughout the day. You want to see if you can find anything interesting about the times for which you have no data.

First, you set up the graph by drawing a pair of axes on graph paper. The horizontal axis is for the time. Label it TIME OF DAY and write the times under the lines. Notice that the numbers are spaced evenly along the horizontal axis.



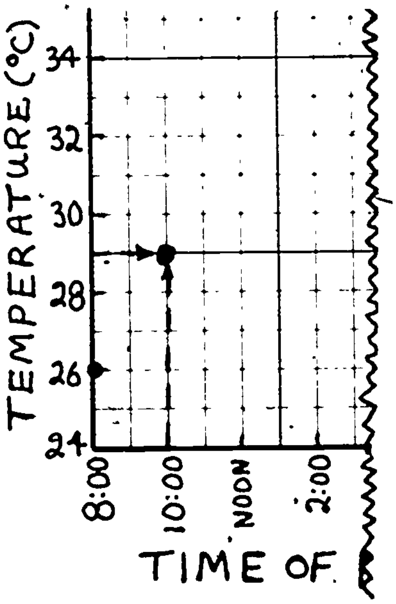
The vertical axis is for the temperatures. Label it and fill in the numbers opposite the tick marks. Because the temperatures on your data chart are 26 degrees Celsius or higher, you don't have to start with 0 degrees on your graph. In this example we begin with 24 degrees.



Now you are ready to plot the points. At 8:00 A.M. it was 26 degrees. Find 8:00 A.M. on the TIME line and then go <u>up</u> to 26 degrees. Make a large dot where those lines meet.

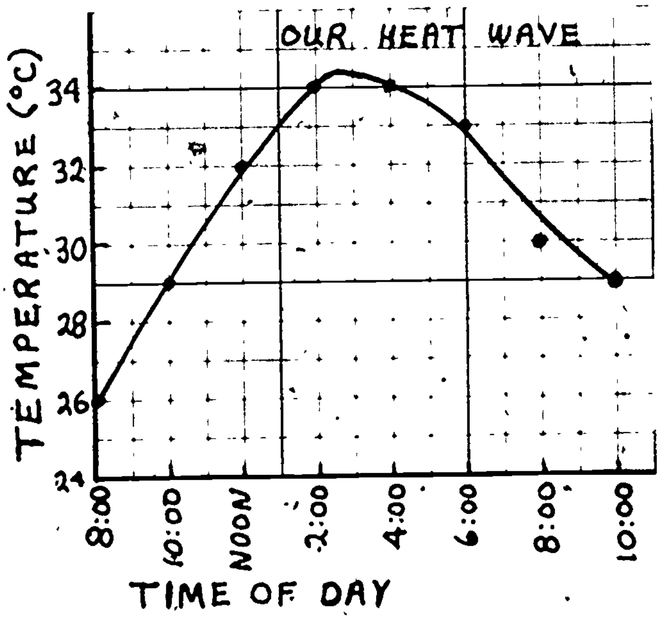
Then plot the next point: Go <u>over</u> to 10:00 A.M. and <u>up</u> to 29 degrees.

Keep plotting points. When you have plotted all the points, draw a smooth line that goes through all or nearly all of the points.

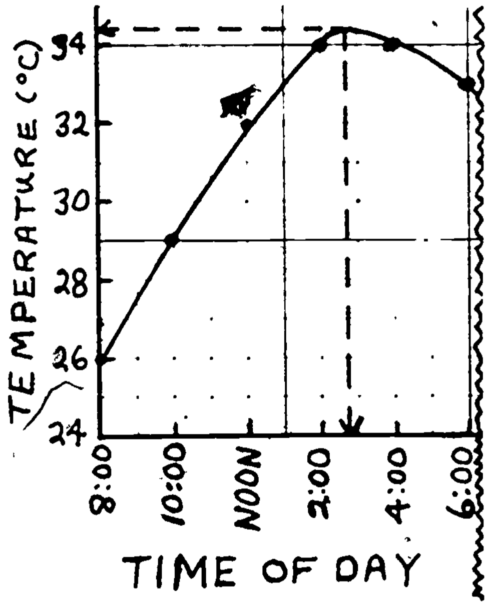


The finished graph looks like this. To draw a line with no sharp bends in it, you had to go above 34°C between 2:00 P.M. and 4:00 P.M. You went above 34°C just enough to make the line smooth.

You can see that as the day went on, the temperature got higher. Then it reached a peak just above 34°C and began to fall. You can also tell that it was as hot at 10:00 at night as it was at 10:00 in the morning.



"At what time was the temperature highest?" you might wonder. You can interpolate from the graph to figure that out. Find the peak of the curve.. Run your finger down in a straight line to the TIME OF DAY line. You end up at a point that is about halfway between 2:00 P.M. and 4:00 P.M. So you can say that the temperature was probably highest around 3:00 P.M. that day.



Making a line graph helped you find out information that you didn't have on the data chart. The reason that you can interpolate is that the spaces between the lines in your measurements make sense.

COMPARING THE GROWTH OF TWO PLANTS

So far, you have learned how to make one line graph to find out how one thing is growing or changing. But you can also make two line graphs to compare the growth or change of two things. For example, you can make two line graphs to show the temperature on two days or to show the average daily temperature for two different months. You can use line graphs to compare the weights of two animals. This example shows how you can compare the growth rates of two of the same kind of plant.

Suppose that you and a friend have decided to grow avocado plants. You want to see whether the two plants will grow the same. You will each put a large avocado pit into water. Then you will wait for them to split and grow some roots. As soon as that happens, you will put the pit into a pot of soil and watch your plants grow. You know that the two avocado pits will probably not be ready for potting at exactly the same time, even if they were put into water the same day. So you and your friend agree to pot each avocado pit whenever it is ready. Then each of you will keep track of your plant's height from the day it was put into soil.

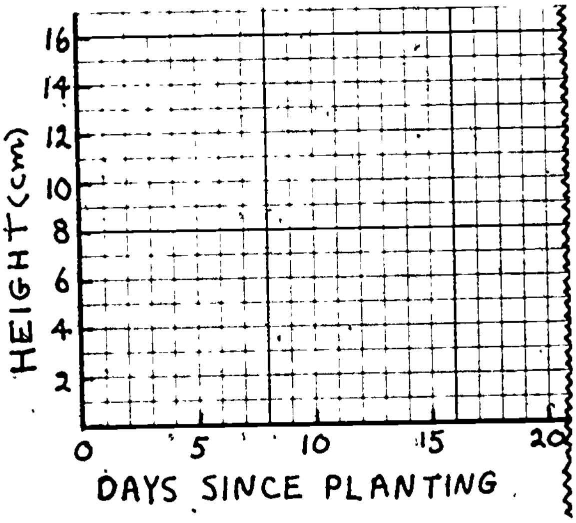
Let's say that your pit was planted on January 7 and your friend's pit was planted on January 18. You agree to measure the heights every 5 days. Each of you makes a data chart.

JIM'S AVOCADO	Jan. 7
Days Since Planted in Soil	Height (cm)
0	0
5	2
10	5
15	9.5
20	12
25	13
30	14
35	14.5

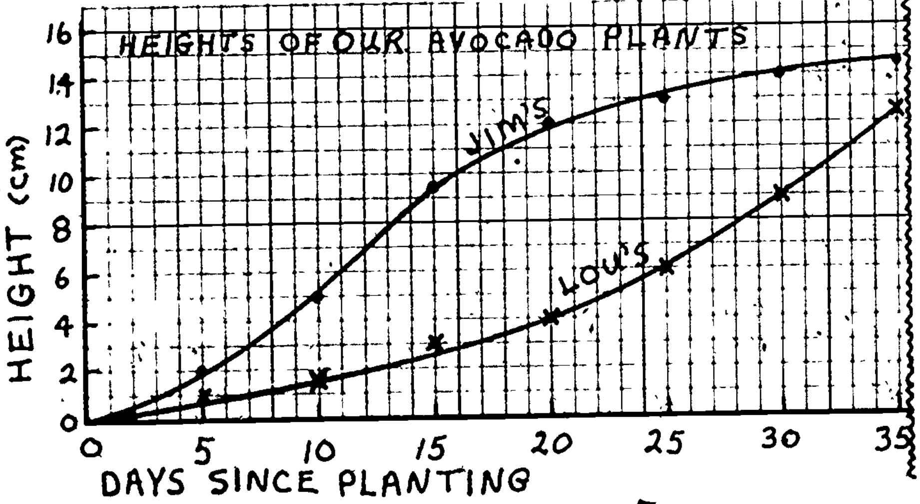
LOU'S AVOCADO	Jan. 18
Days Since Planted in Soil	Height (cm)
0	0
5	1
10	1.5
15	3
20	4
25	6
30	9
35	12.5

You can see from the data charts that on the 35th day, one avocado is 14.5 centimeters tall and the other is 12.5 centimeters tall. That is a difference of 2 centimeters. But you would like to compare how fast each of the plants grew. You will make two line graphs to compare their rates of growth.

Set up the graph. Label the horizontal axis DAYS SINCE PLANTING and write the numbers along the lines. Label the vertical axis HEIGHT (cm) and write the numbers for the height. Since the plants started at a height of 0, you should begin with 0 centimeters on the vertical line.



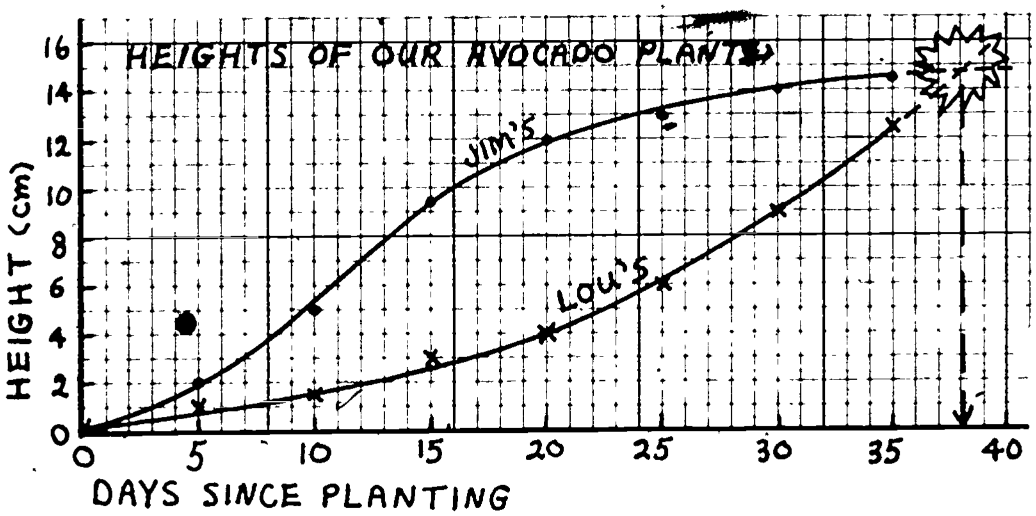
Using the data chart for Jim's avocado, you plot the points. You connect the points with a smooth line. Then you plot the points for Lou's plant and connect those points with a smooth line also. The two finished graphs look like this. What do they tell you about how the plants grew?



You can tell at a glance that the curve for Jim's plant is higher than the curve for Lou's plant. That means that on any given day after planting, Jim's plant was taller than Lou's. You can also see that the two graphs share only one point in common. On Day 0, when each plant was first put into the soil, both heights were 0. (The point where the horizontal and the vertical line meet is called the <u>origin</u>. So the two graphs start out at the origin, but they don't meet again.) Any time after Day 0, the plants were never the same height.

Look at the graph for Jim's plant. It rises steeply for the first 20 days and then it levels off. That means that the plant grew pretty quickly at first, and then slowed down. You could predict that after Day 35 the curve will probably get a bit higher, but it will not shoot up as quickly as it did before. You can say that the plant's rate of growth has slowed down and will probably level off at some time.

Now look at the graph for Lou's plant. It starts off much more slowly. The curve isn't as steep as it is for Jim's plant. That means that Lou's plant grew more slowly. But notice that at about Day 20, the curve gets steeper. Even at Day 35 it still seems to be rising. Lou's plant has grown quickly from Day 20 to Day 35. You could predict that Lou's plant will continue to grow quickly. In fact, Lou's plant might be as tall as Jim's plant in about three more days. Then the graphs might look like this:



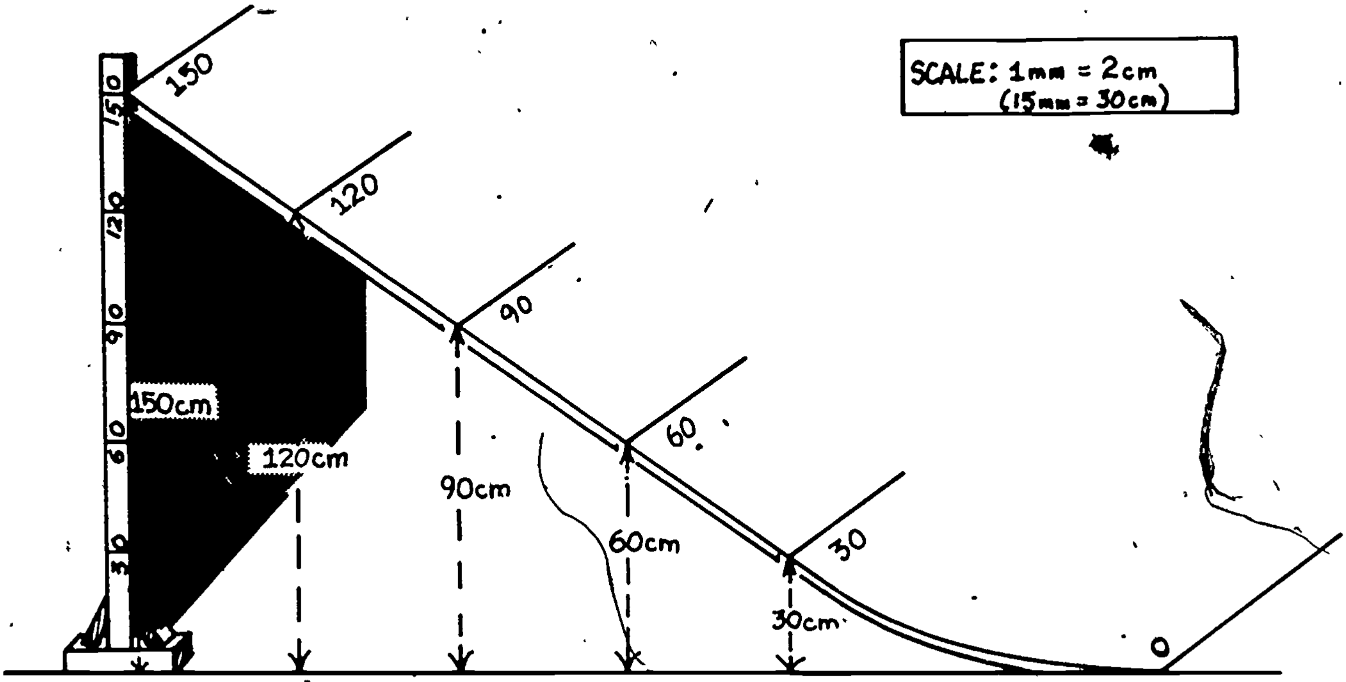
There is no way to tell for sure, but you can make a pretty good guess about what will happen to each of the plants, just by looking at the graphs of how they <u>have</u> grown.

When you look at the line graph to predict other measurements beyond those that you know, you are using <u>extrapolation</u>. When you extrapolate, you make a guess about where the next points might be. You base your guess on what you know about the graph so far. You must be careful when you extrapolate because the direction of the line might change and make your guess wrong. When you extrapolate, you should have a large number of points already on your graph. You should never extrapolate from just four or five points.

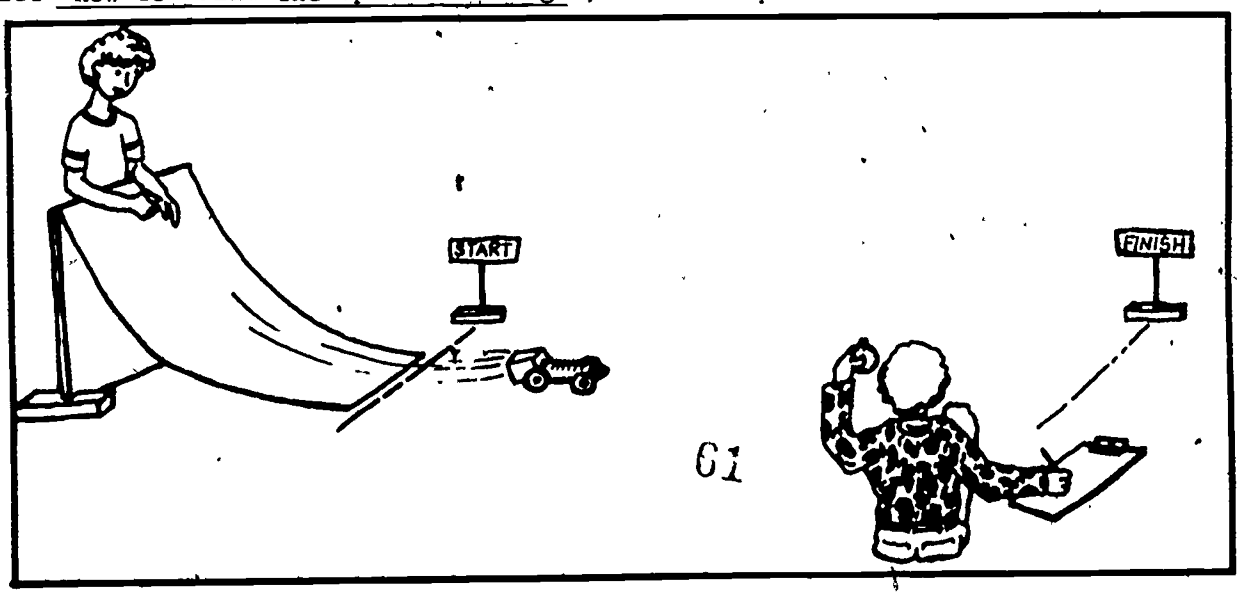
TESTING THE SPEED OF A MODEL CAR

Suppose that you and some friends have become interested in how fast model cars travel across a level floor when they start off on a hill. One person thinks that how fast a car rolls depends on how high on a hill it starts off. Others are not so sure, so you decide to do an experiment.

You make a wooden ramp like the one shown below. You fix it so that the top is 150 centimeters from the floor. Then you make equal markings on the ramp to show the height from the floor every 30 centimeters. You make a START line on the level floor at the bottom of the hill. You mark a STOP line 5 meters from the START line.



You begin the experiment. First you put the car at the top of the ramp and let go. The car rolls down the ramp and across the floor. When the front of the car crosses the START line, you start a stopwatch. When the front of the car crosses the STOP line, you stop the stopwatch and read the time. Then you compute the speed of the car. (If you need help in doing this, read the booklet "How To" Find the Speed of Things.)



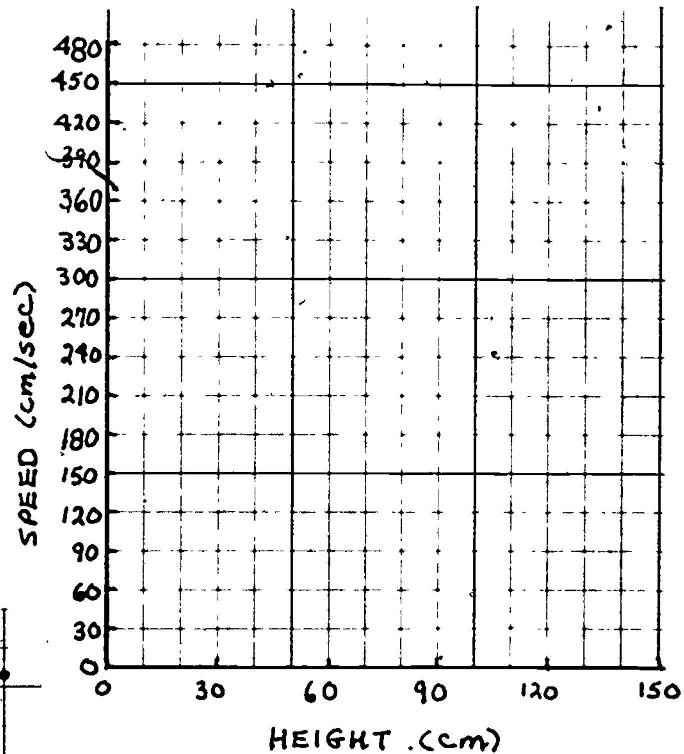
Each time you start the car at a different height on the ramp. Each time you figure out the speed. Here is what you have found.

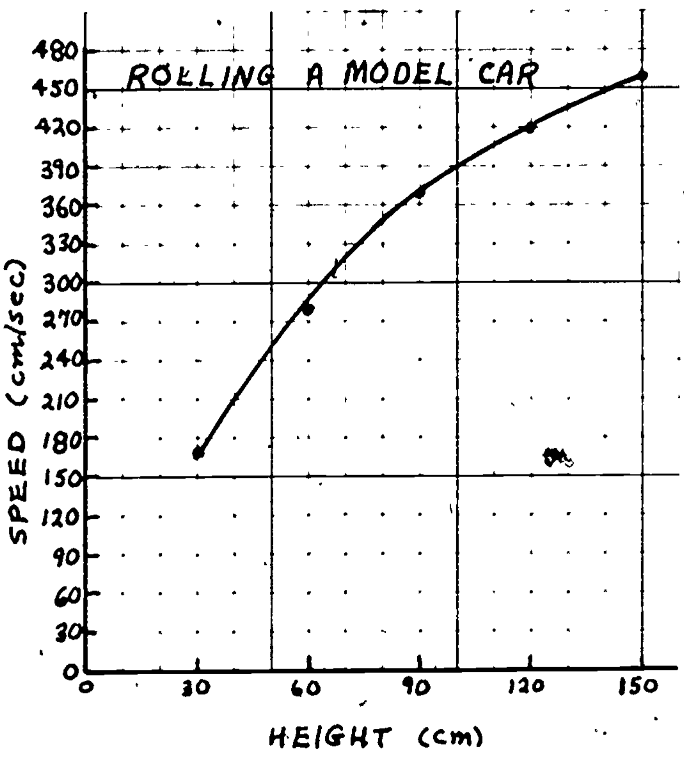
ROLLING A MODEL CAR	Nov. 20
Height Started (cm)	Speed of Car (cm per sec.)
150	460
120	420
90	380
60	270
30	170

You would like to see how the speed changes, so you decide to make a line graph.

Set up the graph by drawing a pair of axes: Put the height along the horizontal axis and the speeds along the vertical axis. Label each axis and fill in the numbers. Notice that each space along the bottom axis stands for 10 centimeters. Each space along the side axis stands for a speed of 30 centimeters per second.

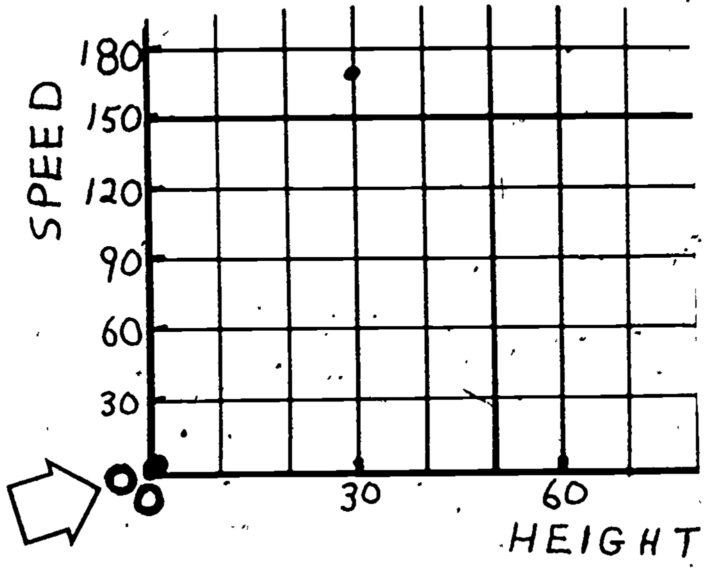
Then, using the data chart, plot the points. The finished graph looks like this.





You can see that as the numbers for the height get larger, the numbers for the speed also get larger. That means that when the car started at the top of the ramp its speed was faster than when it started at the middle or the lower part of the ramp.

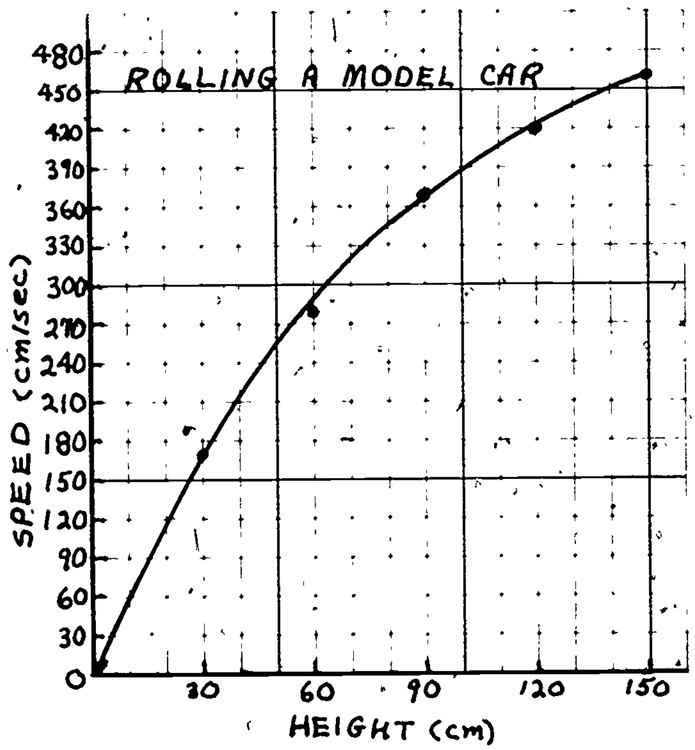
Look at the part of the graph near the origin. What do you suppose would happen if you started the car at a height of 0 centimeters? Common sense tells you that the car wouldn't roll at all. Its speed would be 0 centimeters per second. So you can plot the point for 0 centimeters height, 0 centimeters per second speed. That point is at the origin.



Measurements for very short heights and very slow speeds would be almost impossible to make, but the point at the origin helps you draw the line for your graph. You draw a smooth line through or near all the points. The point at the origin connects to the next point with a smooth line.

You can interpolate other data from this line graph, too. For example, you can tell about how fast the car will go if you start it at a certain height. Or you can tell about how high to start the car if you want it to go a certain speed.

Of course, these measurements may be very hard to make and there may be many errors in accuracy, but the graph does give you a rough picture of how the speed changes.



DEFINITIONS

Horizontal Axis

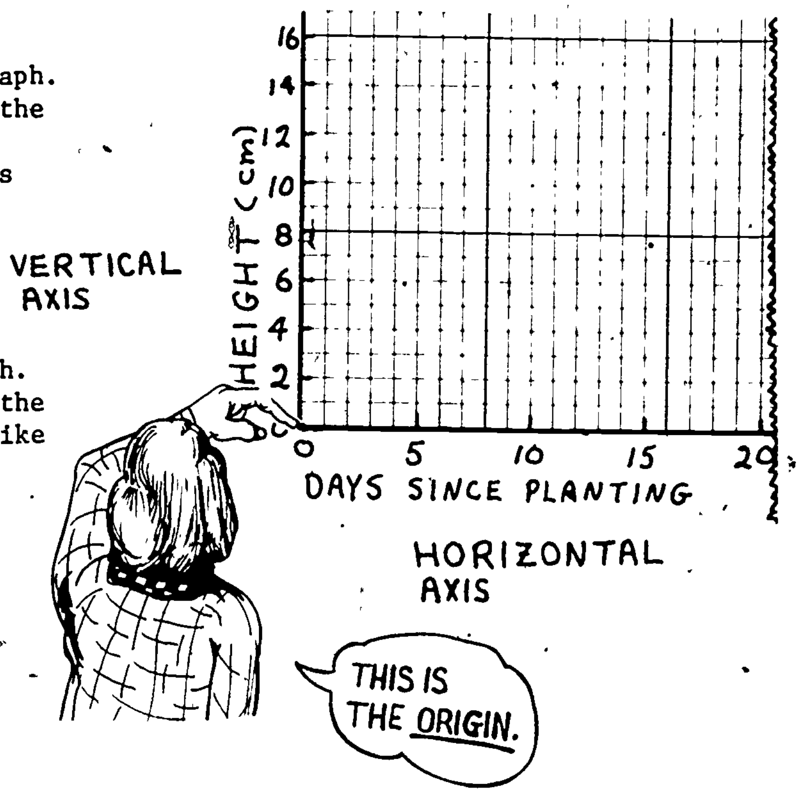
This is the bottom line of the graph. In a line graph, you usually put the measurement that you change (like months or days or time) along this axis.

Vertical Axis

This is the side line of the graph. In a line graph, you usually put the numbers that you have measured (like height or weight or temperature) along this axis.

Origin

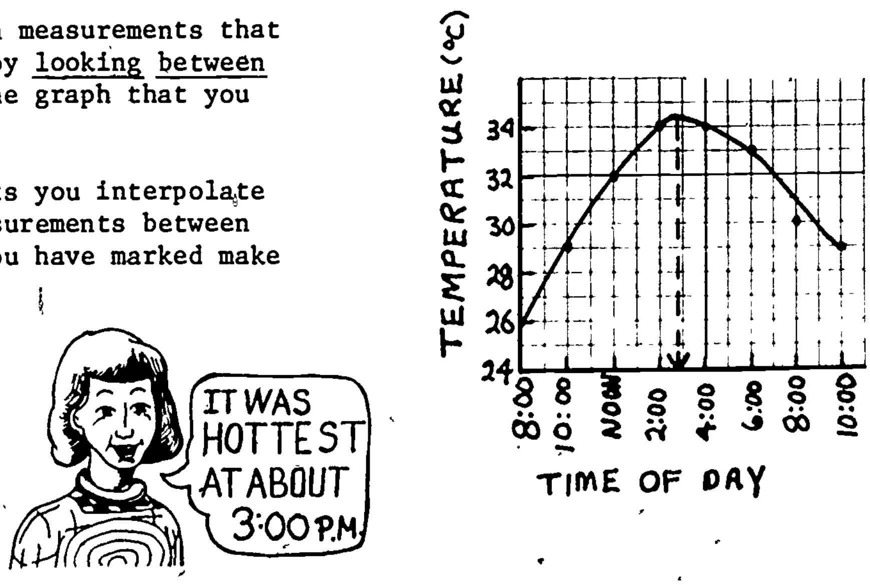
This is the point on the graph where the two axes meet.



Interpolate

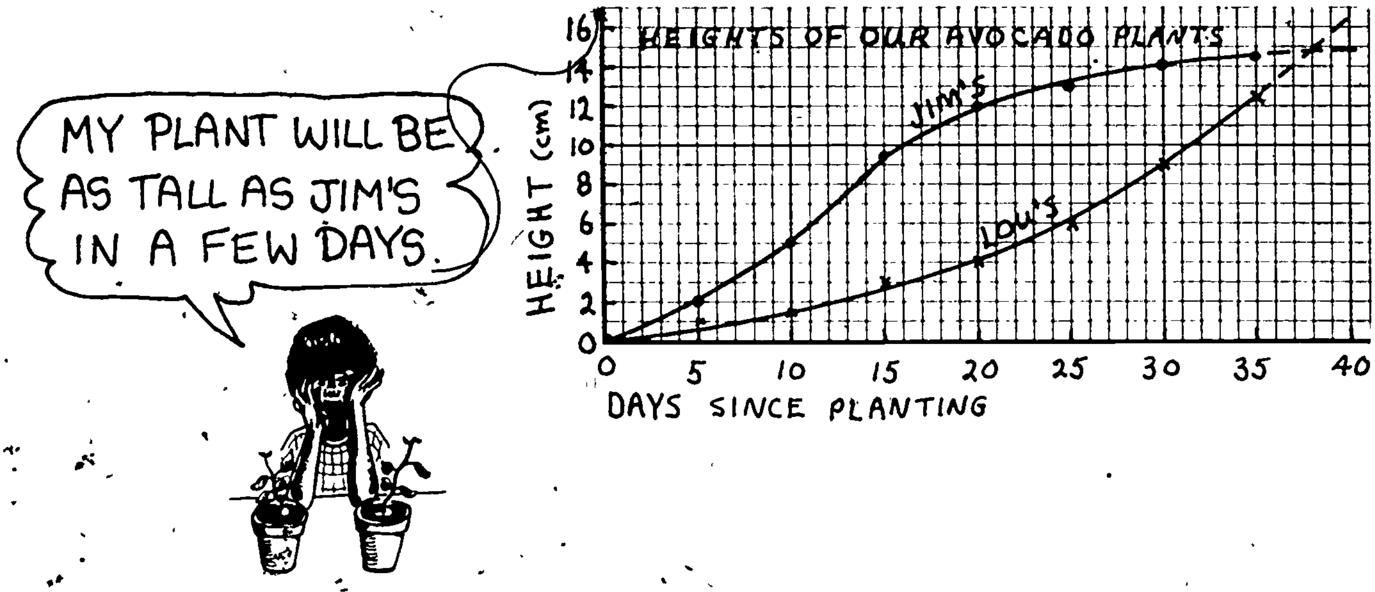
To guess certain measurements that you don't know by looking between the points on the graph that you have measured.

A line graph lets you interpolate because the measurements between the ones that you have marked make sense.



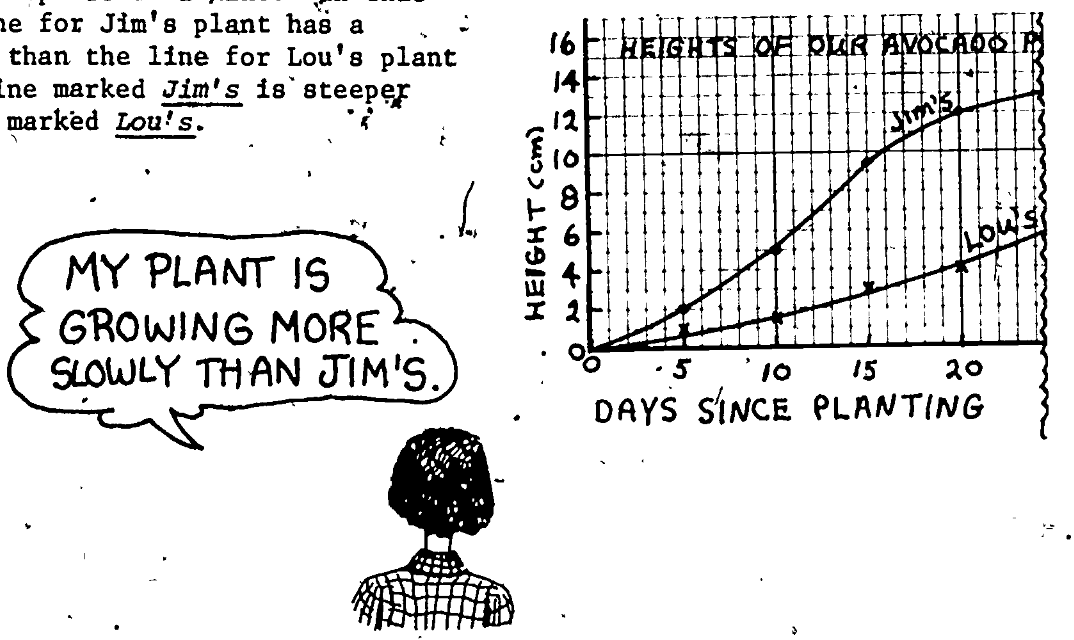
Extrapolate

To guess certain measurements beyond the ones that you know by looking at the pattern of the points on the graph.



Slope

This is the steepness of a line. In this graph, the line for Jim's plant has a greater slope than the line for Lou's plant because the line marked *Jim's* is steeper than the line marked *Lou's*.



THINGS TO KEEP IN MIND ABOUT LINE GRAPHS

IS A LINE GRAPH THE BEST GRAPH TO SHOW YOUR DATA AND ANSWER YOUR QUESTIONS?

- Are both parts of your data measurements?
- Do you want to find out how something is growing or changing?

If your answer to both questions is "yes," a line graph is probably a good graph to make.

If you answered "no" to either question, you might want to make another kind of graph. The booklets "How To" Choose Which Graph to Make for One Set of Data and "How To" Use Graphs to Compare Two Sets of Data might help you find a better graph for your data.

THINGS TO REMEMBER WHEN YOU DRAW YOUR LINE GRAPH

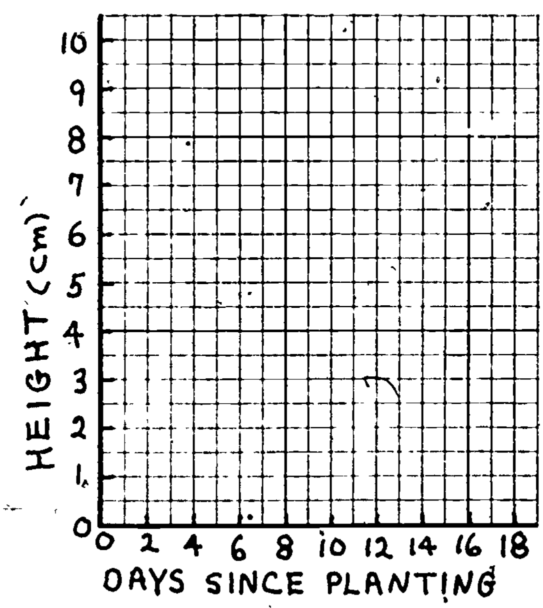
1. Draw the axes carefully. Follow the lines of the graph paper. Write what each of the axes stand for.

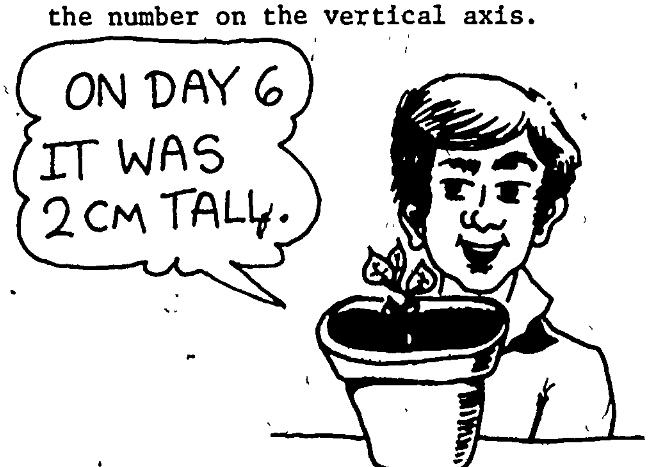
2. Put the measurement that you change along the horizontal axis. Put the thing that you are measuring along the vertical axis.

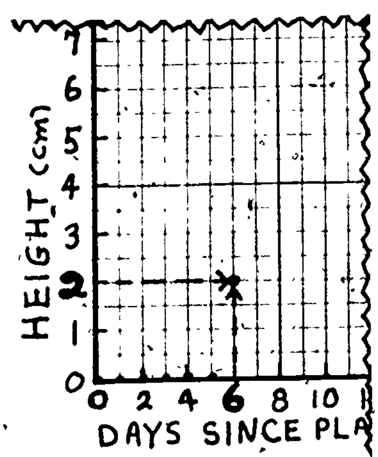
3. Write the numbers along the lines, not in the spaces. The tick marks will show what lines the numbers stand for.

4. If you don't have enough room on the graph paper, make each space stand for a difference of more than one unit of measure.

5. To plot a point, go over to the number on the horizontal axis and then up to the number on the vertical axis.

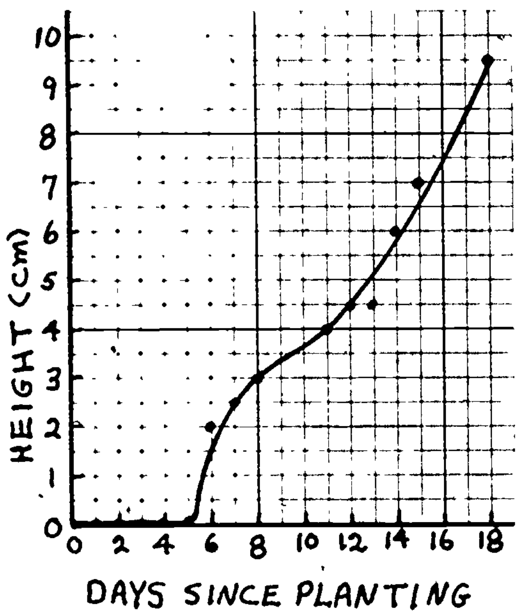


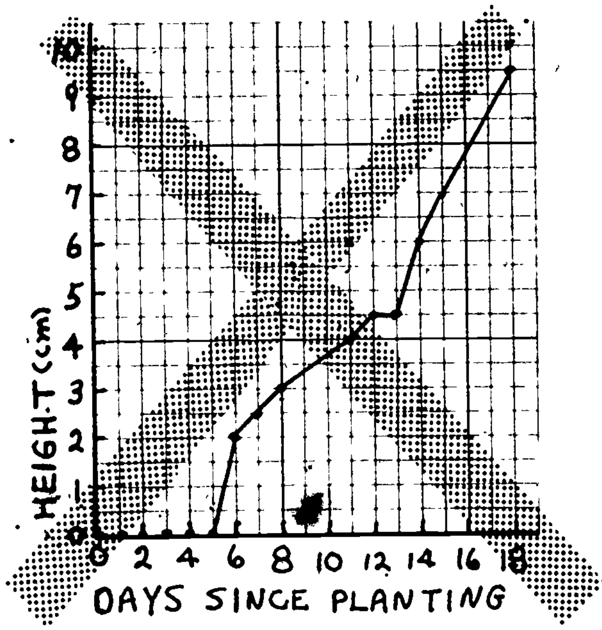




6. Be sure to have enough points so that you can tell what the pattern looks like.

7. Draw a smooth line that goes through all or nearly all of the points on your graph. Don't make sharp bends. Because there are small errors in all measurements, some of the points may not be right on your line. If some points look as if they fall way outside the pattern, check your measurements again.





8. Try to figure out what the graph tells you. Can you use interpolation to guess what might be happening between the points that you have plotted? Can you use extrapolation to guess what might happen beyond the points that you have plotted?

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"HOW TO"

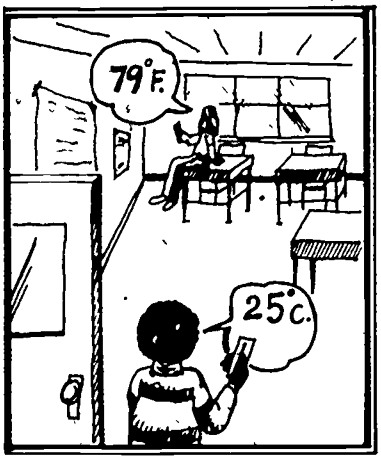
MAKE A CONVERSION GRAPH

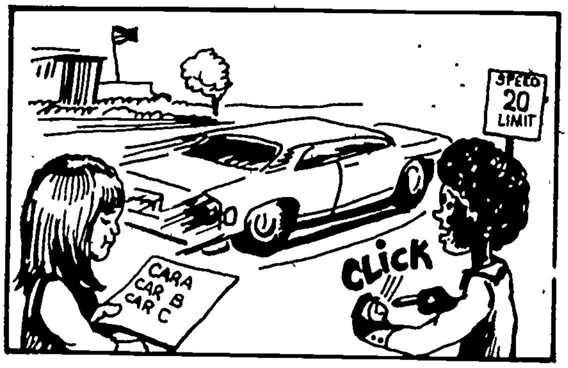
A CONVERSION GRAPH IS ALSO A LINE GRAPH.

SEE "HOW TO" MAKE A LINE GRAPH.

DO YOU HAVE MEASUREMENTS IN ONE UNIT THAT YOU NEED TO CHANGE TO A DIFFERENT UNIT?

Perhaps you need to change servings to quarts to make a large quantity of soft drink. Perhaps you have temperature measurements in Fahrenheit degrees that you want to change to Celsius degrees. Perhaps you have found the speeds of cars in meters per second, and you need the speeds in miles per hour. Then you can make a CONVERSION GRAPH.





WHAT IS A CONVERSION GRAPH?

A conversion graph is a line graph that tells you what measurements in one unit are in a different unit. It tells you how to change--

- servings to quarts
- ounces to quarts
- Fahrenheit degrees to Celsius degrees
- centimeters to spaces on a scale drawing
- meters per second to miles per hour

and many others.

This booklet will show you how to make several different conversion graphs.

WHAT'S INSIDE — PAGE

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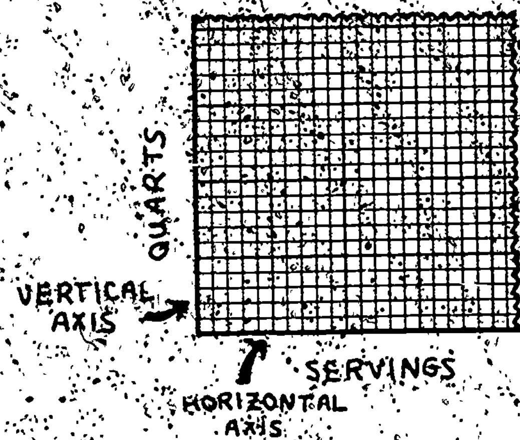
HOW MUCH DRINK TO MAKE: CHANGING SERVINGS TO QUARTS

Suppose that you are going to make a soft drink to sell at lunch time to the other students in your school. From a survey you have conducted, you know that 92 students have said they would buy one 5-ounce serving of drink.

But your recipe for your drink is for one quart of drink. How many times must you make your recipe to serve all 92 students? You need to know how many quarts there are in 92 servings of your drink.

First, draw two lines on a piece of graph paper. You will put servings along the bottom line, or horizontal axis, and you will label it SERVINGS. You will put quarts along the side line, or vertical axis, and you will label it QUARTS. Your graph will look like this.



How do you number the axes? That depends on the units you are converting. You will need three points to draw your conversion line. You will need to know how much three amounts in one unit are in the other unit. Before you can number the axes, you need to know what your three points will be.

One point is easy to find. A measuring pitcher that is empty has no servings in it. It also has no quarts in it. That means that

0 servings = 0 quarts

0 SERVINGS = 0 QUARTS

How do you get the other two amounts? You should choose one of them so that it is close to the largest measurement you want to convert. That means you need one amount near 92 servings. First, you find out how many servings are in one quart.

You know that

1 serving = 5 ounces

and that

1 quart = 32 ounces.

ERIC

To find out how many 5-ounce servings are in 1 quart, or 32 ounces, you divide 32 ounces by 5 ounces:

$$\begin{array}{r} 6.4 \\ 5\overline{)32.0} \\ \underline{30} \\ 2\,0 \\ \underline{2\,0} \end{array} \quad \Rightarrow \quad 1 \text{ quart} = 6.4 \text{ servings}$$

You find that there are 6.4 servings in one quart. You could use that as one of your points, but 6.4 may be hard to find on your graph. You can get another point by multiplying by 10. You found that

6.4 servings = 1 quart

so that

64 servings = 10 quarts

You can double this to get another point:

128 servings = 20 quarts.

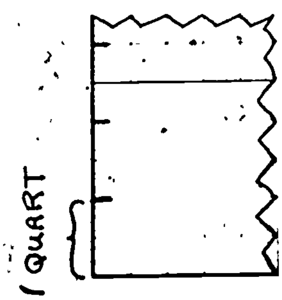
This amount, 128 servings = 20 quarts is good to use because it is close to 92 servings.

That gives you the three points you need to draw your conversion line. You have

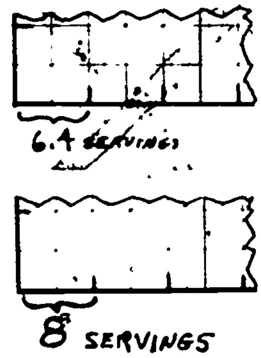
0 servings = 0 quarts
64 servings = 10 quarts
128 servings = 20 quarts

But you still have to number the axes. How will you do this? You want the line you draw to be as long as possible. It will be more accurate that way. This means that you should go up about as many spaces for 1 quart as you go over for 6.4 servings. The number of spaces do not have to be exactly the same, but they should be close to the same.

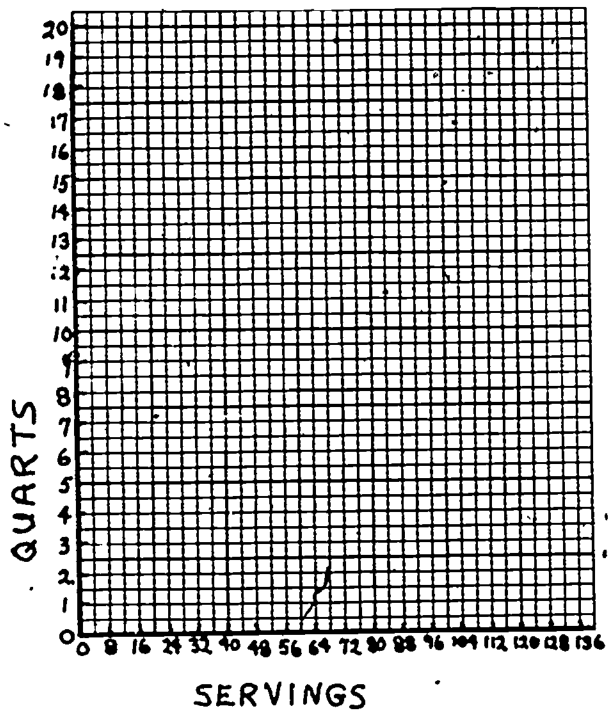
How many spaces should you use for 1 quart? You could let 1 space stand for 1 quart, or 2 spaces, or 4 spaces, or perhaps more. But remember that you must go all the way out to 20 quarts. So don't use too many spaces for 1 quart, or you'll go off the edge of your graph paper. Here, you can let 2 spaces stand for 1 quart.



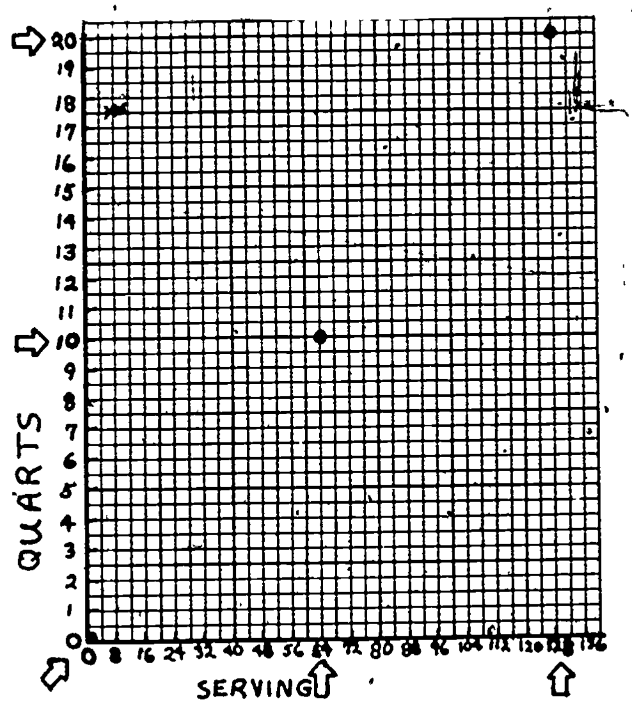
How should you number the SERVINGS axis? You should go over the same number of spaces for 6.4 servings as you went up for 1 quart. That means you can let 2 spaces stand for 6.4 servings. But that would make the lines stand for fractions of servings. It will be much easier to let 2 spaces stand for 8 servings. That's close enough to 6.4 servings to draw a good conversion line.



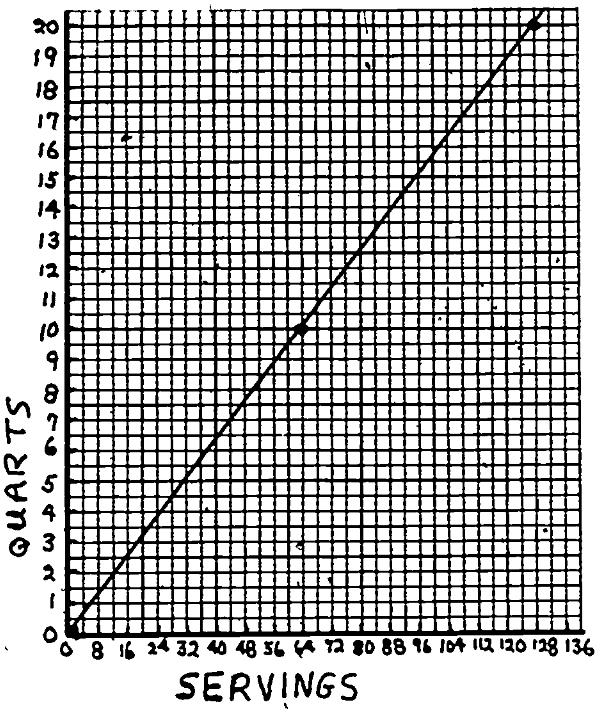
Number your axes. Let 2 spaces stand for 1 quart on the vertical axis. Let 2 spaces stand for 8 servings on the horizontal axis. Your graph will look like this.



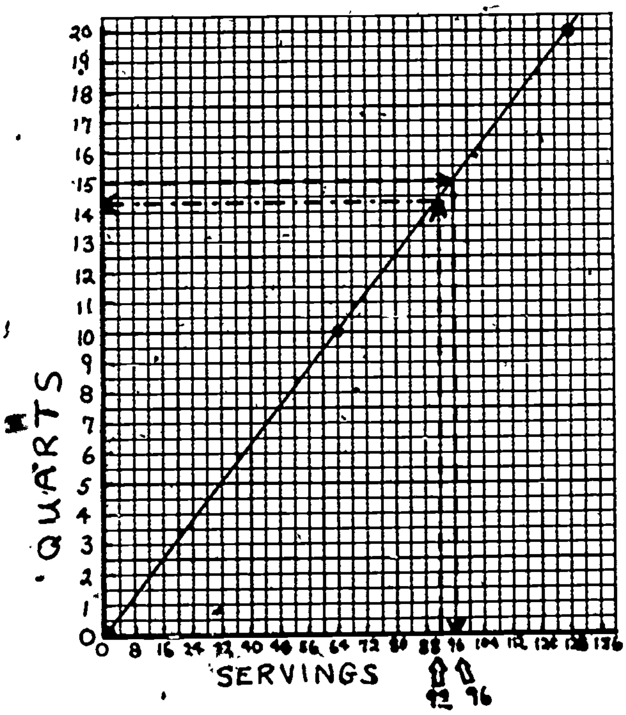
Now you can put on the points. Put on the point for 0 servings = 0 quarts. Put on the point for 64 servings = 10 quarts. Then put on the point for 128 servings = 20 quarts. Your graph will look like this.



Draw a straight line through all three of your points. That is your conversion line. It will tell you how many quarts there are in a given number of servings. It will also tell you how many servings are in a given number of quarts. Now your graph looks like this.

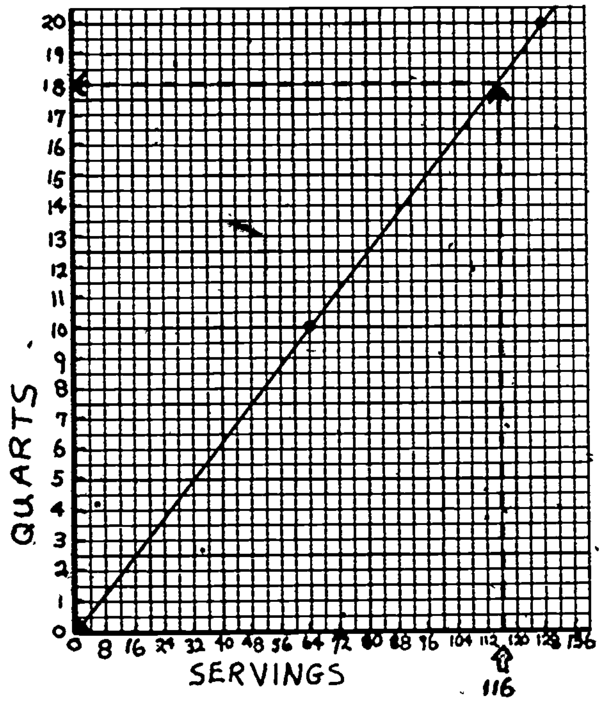


Now you can find out how many quarts are in 92 servings. Go over to 92 on the SERVINGS axis. Then go up to your conversion line. Then go across to the QUARTS axis. You find that 92 servings is a little more than 14 quarts.



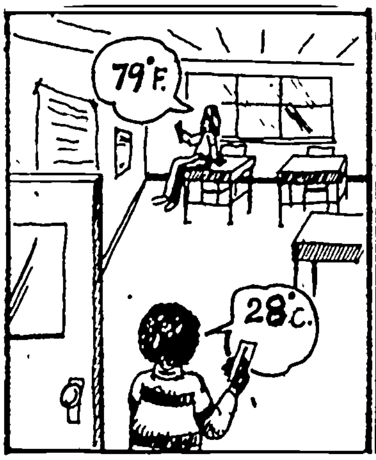
Now you know how much drink to make. You should make a little over 14 quarts. The graph shows that if you made 15 quarts, you would have enough for 96 people.

Suppose that your drink is very popular and that it sells out quickly. There are a number of students that want to buy some but can't because none is left. You can count these students and figure that you could have sold 24 more servings. That's a total of 92 servings + 24 servings, or 116 servings. You look on your graph and see that 116 servings is 18 quarts. You decide to make 18 quarts of drink for your next sale.



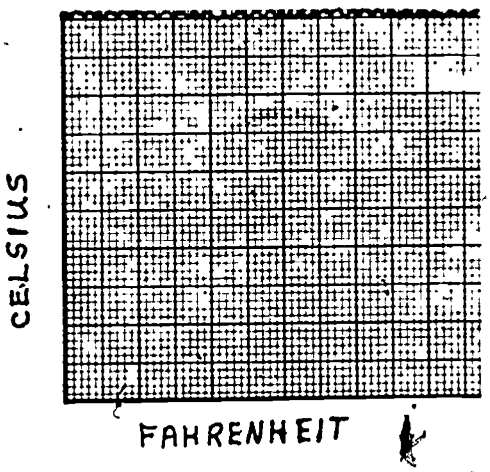
WHAT IS THE TEMPERATURE? CHANGING FAHRENHEIT TO CELSIUS

Suppose you have measured the temperature at five different places in your classroom. Your data look like this:



Date	Location	Temperature
Jan. 21	Teacher's Desk	24°C
	Windows	79° F.
	Beside Closet	28°C
	Cabinet	81° F.
	Chalkboard	22° C

You want to compare the temperatures, but they are in different units. Three of your thermometers are Celsius thermometers and two of them are Fahrenheit. You need to convert your Fahrenheit temperatures to Celsius.

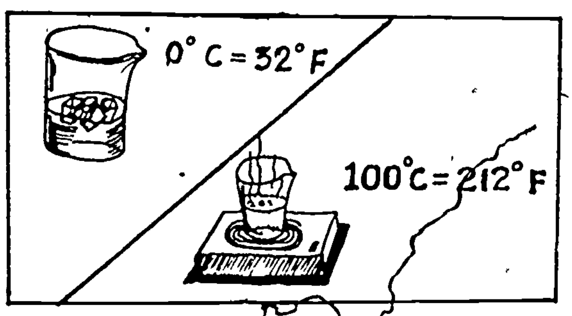


A conversion graph will help you to do this. It will tell you what 79 degrees Fahrenheit is in degrees Celsius and what 81 degrees Fahrenheit is in degrees Celsius.

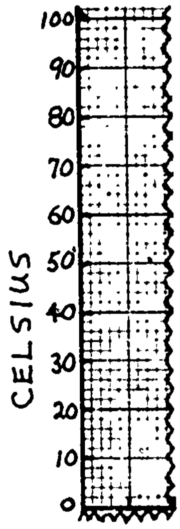
First draw two lines on a piece of graph paper. Label the horizontal axis FAHRENHEIT and label the vertical axis CELSIUS.

Before you can put on the numbers or draw the conversion line, you need to know what three Fahrenheit temperatures are in degrees Celsius.

You may already know two of these. Water freezes at 32° Fahrenheit or 0° Celsius. That's one temperature in both units. Water boils at 212° Fahrenheit or 100° Celsius. That's a second temperature in both units. A third temperature in both units is 68° Fahrenheit or 20° Celsius. This is often called room temperature.

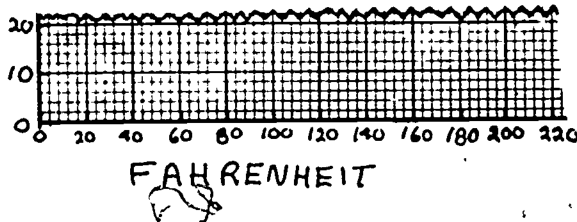


Now, how do you number the lines? You want your conversion line to be as long as possible. That will make it more accurate and easier to use. You need to go from 0°C to 100°C on the Celsius axis.

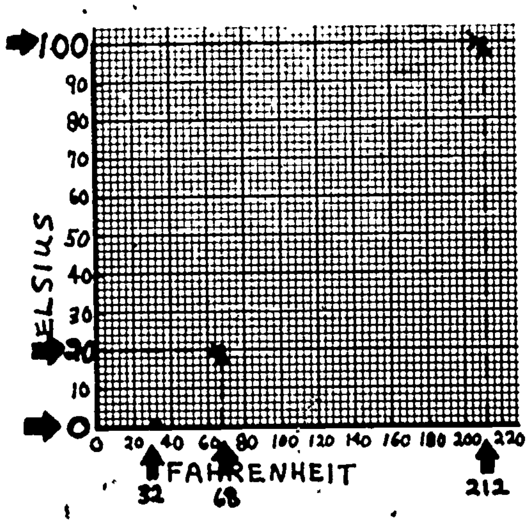


Suppose you let each space on the Celsius axis stand for 2°C. Then you would number the Celsius axis like this. You would use 50 spaces for 100°C.

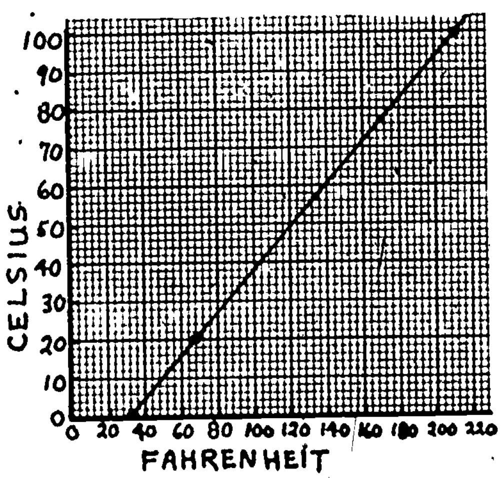
On the Fahrenheit axis you need to go from 0°F. to 212°F. Because you used 50 spaces on the Celsius axis, you should use about 50 spaces on the Fahrenheit axis. You should use about 50 spaces to go from 0°F. to 212°F. If you let each space stand for 4°F., then you would need 53 spaces to go from 0°F. to 212°F. That's close enough to 50 for your purposes. You then number the Fahrenheit axis like this.



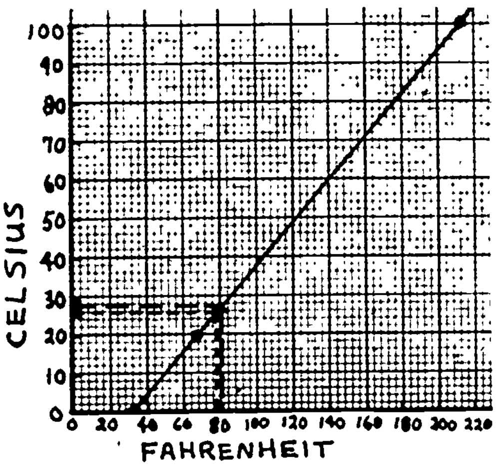
Now you can put on the point for 32°F. = 0°C. Then you can put on the point for 68°F. = 20°C and the point for 212°F. = 100°C. Your graph will look like this.

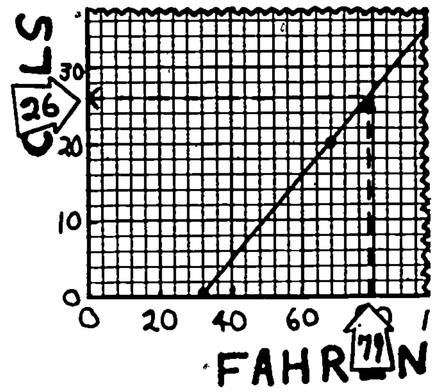


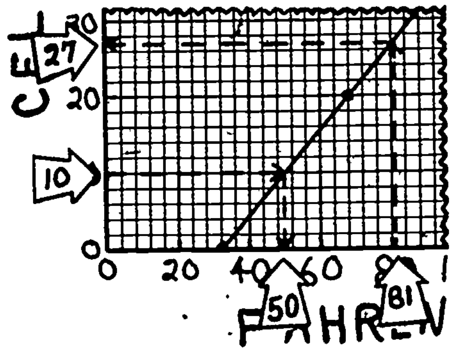
Draw a straight line through your three points. That is your conversion line. Your graph will look like this.



Now you can convert from Fahrenheit temperatures. Go up from 79°F. to your conversion line and over to the Celsius axis. You find that 79°F. is about 26°C. You can also find that 81°F. is about 27°C. You can use all five thermometers to measure temperatures in your room and convert them all to Celsius using your conversion graph.

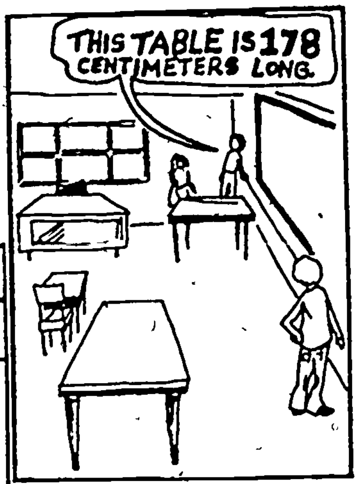






You can also convert Celsius to Fahrenheit. The graph shows that 10°C is about 50°F.

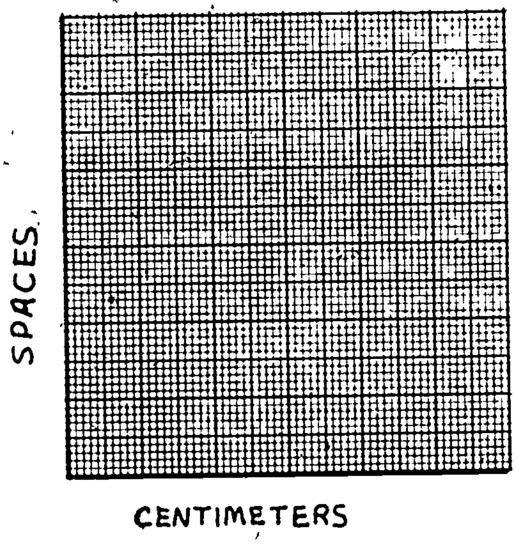
USING A CONVERSION GRAPH WHEN MAKING A SCALE DRAWING



You may have measured your classroom and the things in it so that you can make a scale drawing. Your measurements may look like this.

MEASUREMENTS OF OUR ROOM	SEPT. 12	
	LENGTH (cm)	WIDTH (cm)
ROOM	985	650
BLACKBOARD	668	—
ART TABLE	178	65
BOOK SHELVES	90	25
DESKS	58	43
TEACHER'S DESK	109	75
CABINET	65	38
CUPBOARDS	390	—

Then you choose a scale for your drawing. Suppose you let 1 space on your graph paper be 25 centimeters. You could change all your measurements to spaces on your graph paper by dividing each one by 25. But it is much easier to make a conversion graph. Then you can find the number of spaces for each measurement from the graph. You can convert centimeters to spaces.



Draw two lines on your graph paper. Label the horizontal axis CENTIMETERS, and label the vertical axis SPACES.

You need three points to draw your conversion line. One of these can be 0 spaces = 0 cm. (If something is 0 cm long, it will be 0 spaces long on your drawing.) You get the other points from the scale you chose:

1 space = 25 cm.

It is better to have one point close to your largest measurement. That measurement is 985 centimeters for the room length. You should have a point close to that. If 1 space = 25 cm, then

4 spaces = 4 x 25 cm = 100 cm

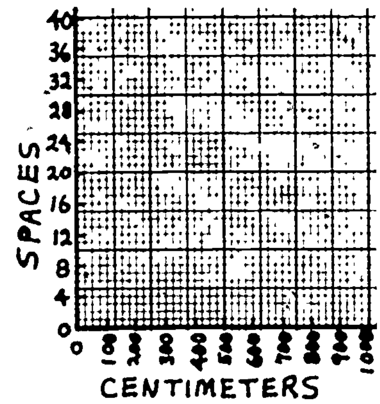
and

40 spaces = 10 x 100 cm = 1000 cm.

1 SPACE = 25 cm
4 SPACES = 100 cm
40 SPACES = 1000 cm

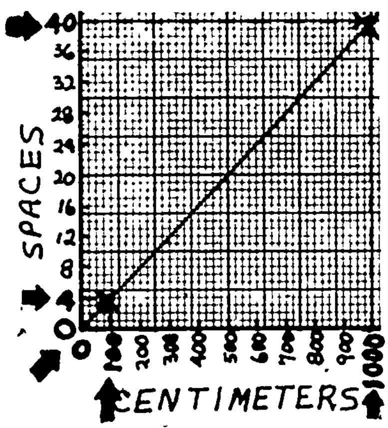
You can use these as the other points that you need.

How do you number the lines? Go out the same number of spaces for 25 centimeters as you go up for 1 space. Let each space on the horizontal axis stand for 25 centimeters. Number the CENTIMETERS axis out to 1000 centimeters.

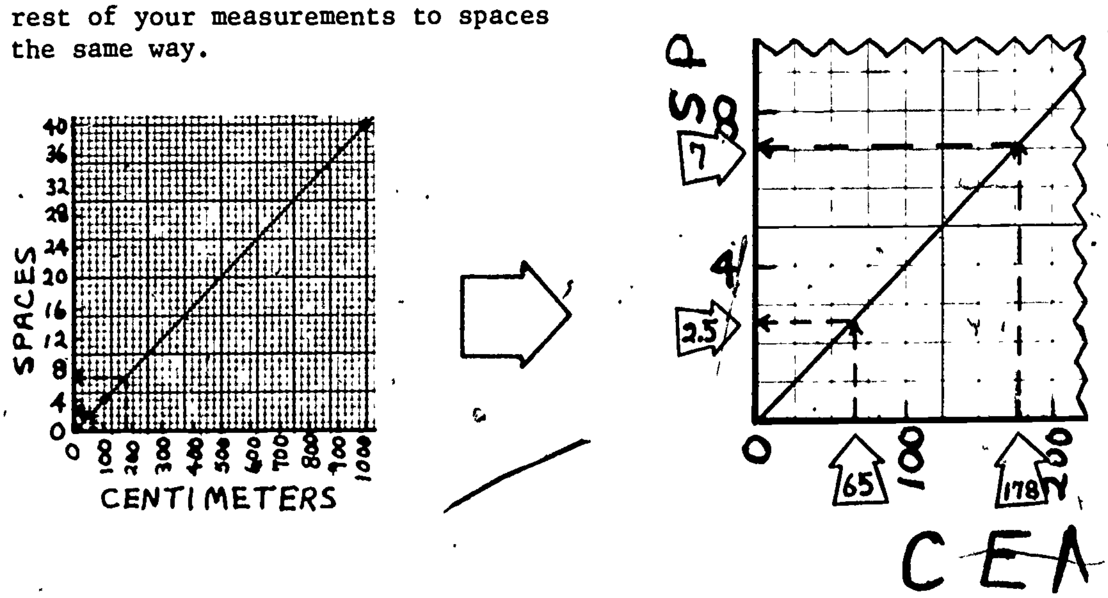


Let each space on the side axis stand for a difference of one space on your scale drawing. Number the SPACES axis up to 40. Your graph now looks like this.

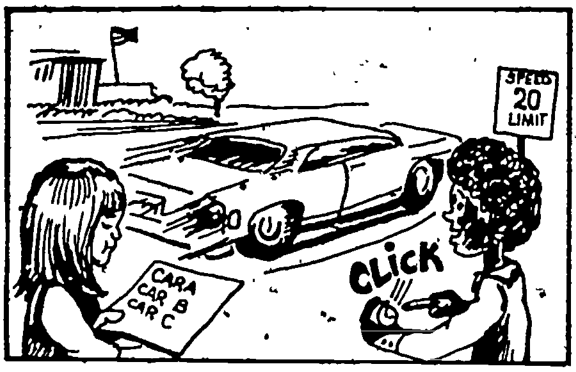
Now you can put on the points to draw your conversion line. First, put on the point for 0 spaces = 0 cm. Then put on the point for 4 spaces = 100 cm and the point for 40 spaces = 1000 cm. Draw a straight line through all your points. Your graph will look like this.



To find out how many spaces to use for the art table, just look on the graph. It is 178 cm long. Go up from 178 cm to your conversion line. Then go over to the side axis for spaces. You find it is about 7 spaces. You can make it 7 spaces on your drawing. The table is 65 cm wide. Go up from 65 cm to your conversion line and over to the side axis. You find that it's about 2.5 spaces. You can make it 2.5 spaces on your drawing. You can convert the rest of your measurements to spaces the same way.



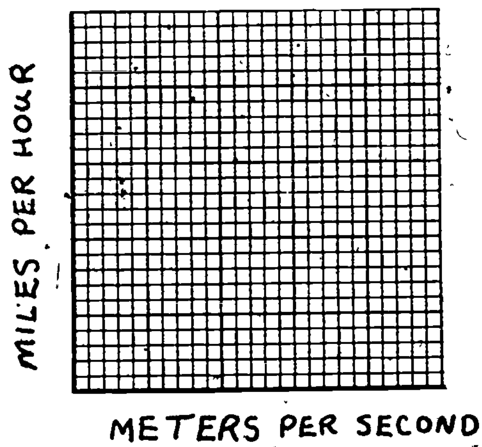
HOW FAST WERE THEY GOING?



Your class may have measured the speeds of several cars in front of your school. You want to know whether any of them were going faster than the 20 miles per hour speed limit. But your data look like this.

SPEED OF CARS		MAR. 21	
CAR	DISTANCE (m)	TIME (sec)	SPEED (m/sec)
A	40	5	8
B	30	5	6
C	50	5	10
D	65	5	13

The speeds are in meters per second, and you want them in miles per hour. You can make a conversion graph to find out the speeds in miles per hour.



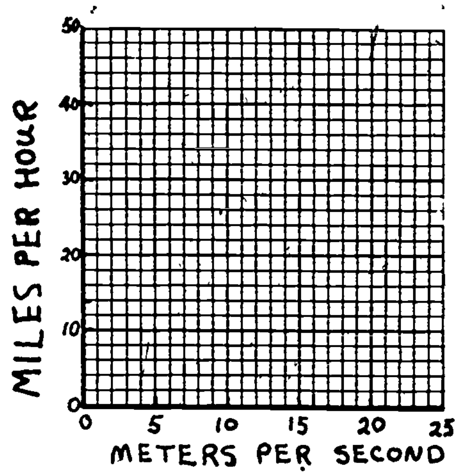
Draw two lines on your graph paper. Label the horizontal axis METERS PER SECOND. Label the vertical axis MILES PER HOUR.

Before you can number the lines, you need to know the three points to draw the conversion line. One of these points is easy to find. A car that isn't moving is going 0 meters per second. It's also going 0 miles per hour. That's one point.

To find two other points, you would have to change seconds to hours and meters to miles. If you did that, you would find that 17 meters per second is very close to 38 miles per hour. It is not exact, but it is good enough for your graph. That's your second point. You would also find that 21 meters per second is very close to 47 miles per hour. That's your third point.

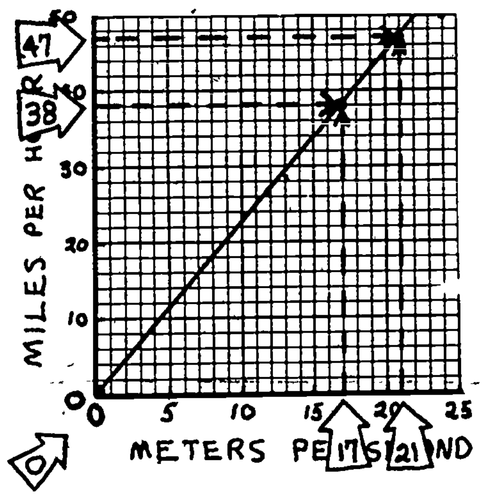
Now look at your data. The largest speed is 13 meters per second. That is smaller than 21 meters per second, which you will use to draw your line. You can see that you must number the METERS PER SECOND axis out to 21. You would probably go out to 25.

You must number the MILES PER HOUR axis up to 47. You would probably go up to 50. You should go out about the same number of spaces for 25 meters per second as you go up for 50 miles per hour.



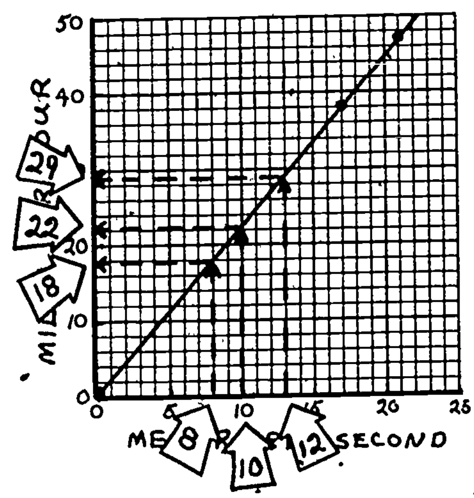
You can let each space on the horizontal axis stand for one meter per second. Number it from 0 out to 25. That will use 25 spaces. (You could also let 2 spaces stand for one meter per second, but your graph might not fit on the paper.)

Then you let each space on the vertical axis stand for 2 miles per hour. Number it from 0 out to 50. That will use 25 spaces. Your graph will look like this.



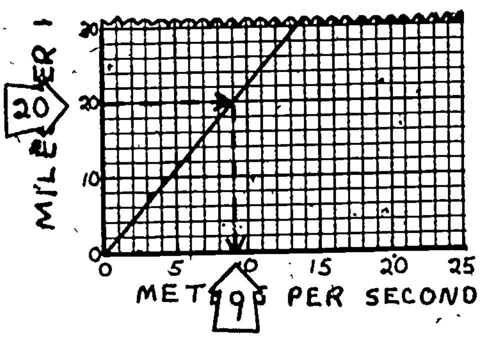
Now put on your three points. First, put on the point for 0 meters per second and 0 miles per hour. Then put on the point for 17 meters per second and 38 miles per hour and the point for 21 meters per second and 47 miles per hour. Draw a straight line through all three points. Your graph will look like this.

Now you can use your graph to convert your measurements to miles per hour. To find 8 meters per second, go over to 8 on the METERS PER SECOND axis and up to the conversion line. Then go across to the MILES PER HOUR axis. You read the answer as 18 miles per hour.



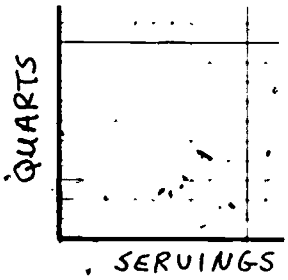
In the same way you find that 10 meters per second is about 22 miles per hour. You also find that 13 meters per second is about 29 miles per hour. You can convert speeds from meters per second to miles per hour using your graph.

You can also convert from miles per hour to meters per second. You find that the speed limit of 20 miles per hour is 9 meters per second.



THINGS TO REMEMBER WHEN YOU DRAW YOUR CONVERSION GRAPH

1. Draw the axes carefully. Follow the lines of the graph paper. Label each of the axes.

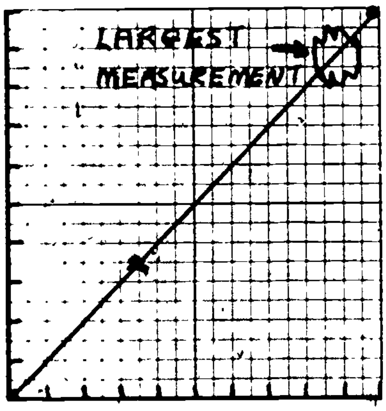


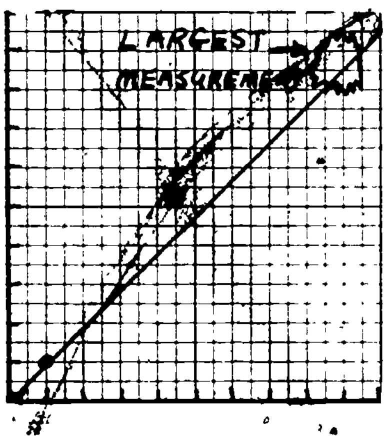
2. Find out how much three amounts in one unit are in the other unit. You need at least three points to draw your conversion line.

   Choose one of the amounts so that one point will be as far out on the graph as the largest measurement you want to convert.

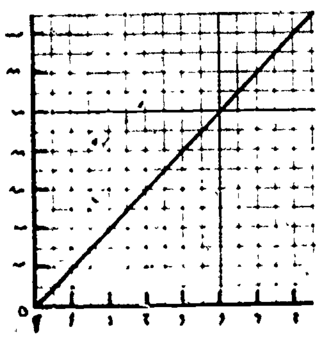
0 Servings = 0 quarts
64 servings = 10 quarts
128 servings = 20 quarts

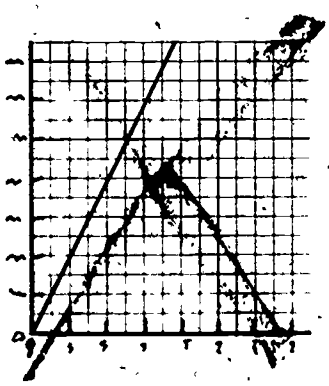
0°C = 32°F
20°C = 68°F
100°C = 212°F

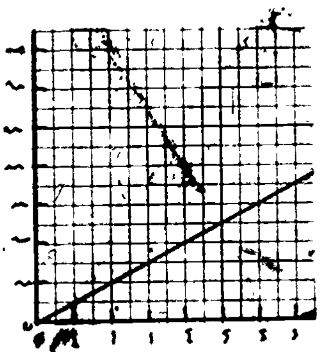




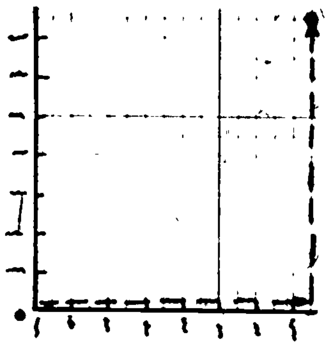
3. Number your axes so that the conversion line is as long as possible. Go out about as many spaces for the amount in one unit as you go up for that amount in the other unit. Make sure that the largest numbers you must use will fit on your graph paper.



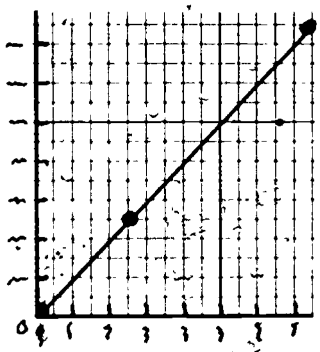




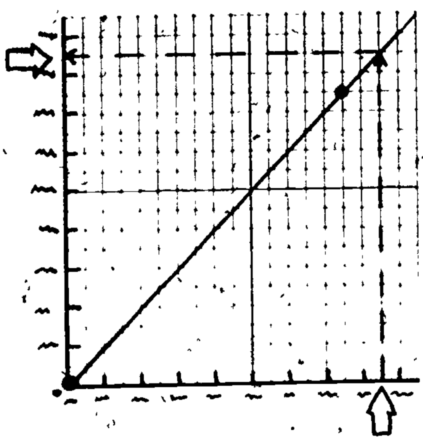
4. To plot a point, go over to the number on the horizontal axis and then up to the number on the vertical axis.



5. Draw a straight line through your three points. Extend it as far as you need in either direction.



6. To convert a measurement, find the measurement you want to convert on the axis for that unit. From there go to the conversion line. Then go to the other axis and read the measurement in the other unit.



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"HOW TO"

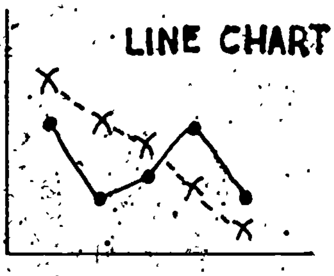
USE GRAPHS TO COMPARE TWO SETS OF DATA

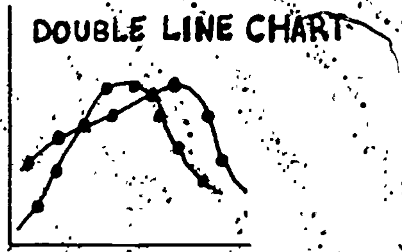
WHY USE GRAPHS?

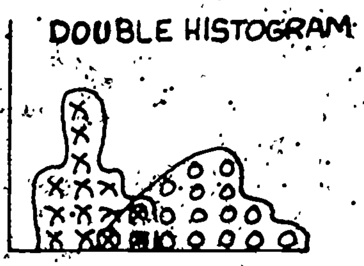
Maybe you have collected two sets of data and you want to compare them. Each set of data may have lots of numbers. It is confusing to try to look at all of the numbers at once. There is an easy way to look at all of the numbers. You can make a graph. The graph will be a picture of both sets of data. You can look at both sets of data without getting mixed up.

WHAT KINDS OF GRAPHS CAN YOU MAKE?

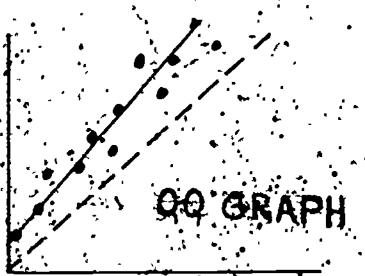
There are two types of graphs you can make to compare two sets of data. One type of graph has two lines on it. There graphs are like that:

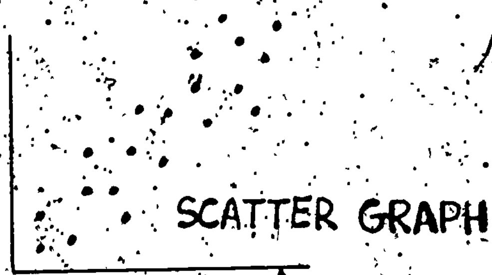






The other type of graph has just one line or a scatter of points. These graphs are like that.





HOW DO YOU DECIDE WHICH GRAPH TO USE TO COMPARE YOUR TWO SETS OF DATA?

There is no simple rule. You will have to think about what kind of data you have. You will have to think about what you want to find out. You may even want to try making several different graphs for your data.

This booklet will help you do these things. The booklet will show you examples of the five graphs that you can make. It will help you choose a graph to compare your data. It will show you how to use graphs to get the information you need.

WHAT'S INSIDE PAGE

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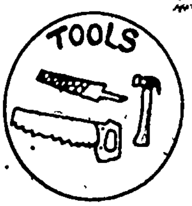
DECIDING WHAT KIND OF DATA YOU HAVE

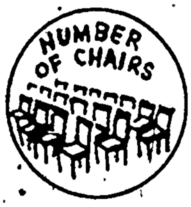
Use this page to decide what kind of data you have. Then read the examples to decide which graph to use to compare your data.

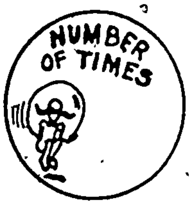
Look at the data you have collected. Your data could be numbers or they could be numbers and words. WHAT ARE THE PARTS OF YOUR TWO SETS OF DATA?

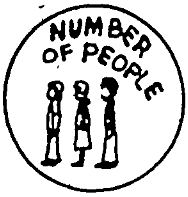
- A list of words? They could be lists of people or tools or foods or months. These can be called SEPARATE ITEMS.



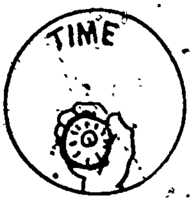
- Numbers? They could be numbers of cars or numbers of children or numbers of times something happens. These can be called NUMBER COUNTS.

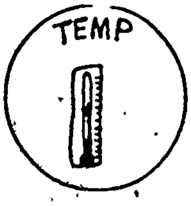




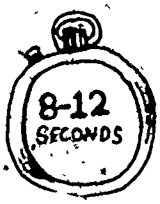


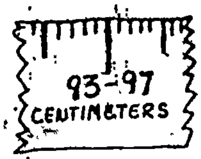
- Times or temperatures or heights or weights? These can be called MEASUREMENTS. You can tell that they are measurements because each number will have a unit, like degrees or centimeters or grams.



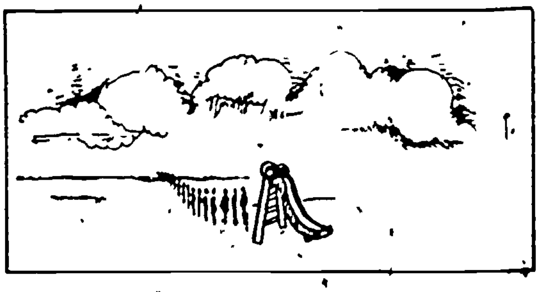


- Sometimes you may want to put your measurements together in clumps, like 8-12 seconds or 41-50 grams or 93-97 centimeters. Then the measurements can be called GROUPED MEASUREMENTS.



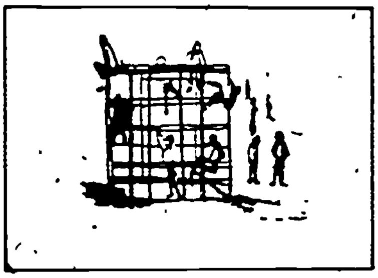


MAKING A LINE CHART



You may want to compare the same type of data collected at two different times or places or from two different groups of people.

- *You may want to compare the morning traffic in front of the school for a week with the afternoon traffic for the same week.*
- *You may want to compare the favorite flavors of soft drinks for two different grades.*
- *You may want to compare which kind of playground equipment younger and older children like*



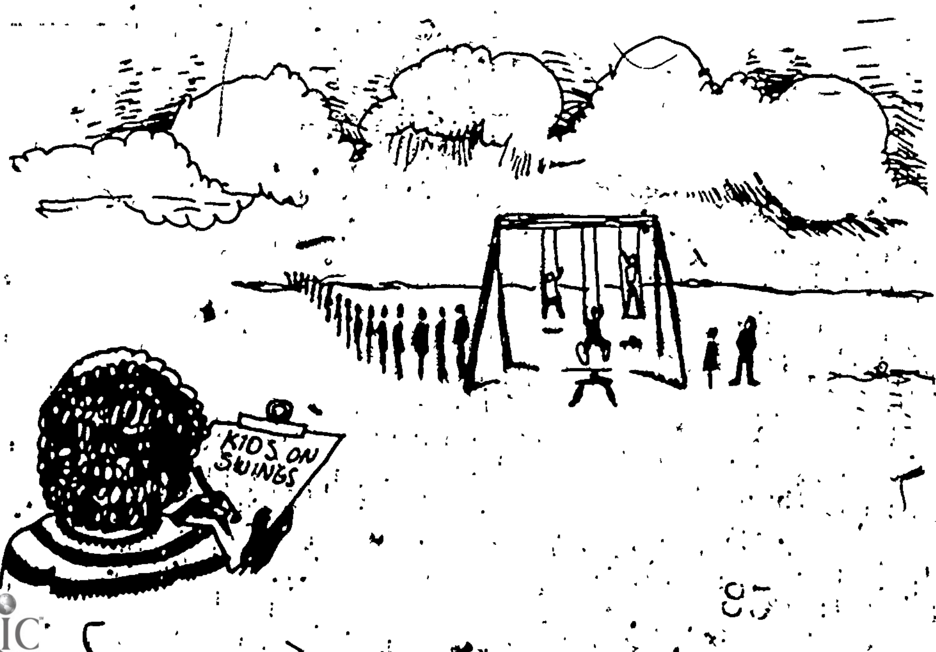
If you are trying to decide something like this, your data will be SEPARATE ITEMS and NUMBER COUNTS. You can make a LINE CHART. Then you can look at all the data at once.

A LINE CHART will make it easier to decide when you need to pick a favorite thing for several groups. That's what Eric and his friends find out in this story.

Eric's class has raised enough money to buy a new piece of equipment for the school playground. But the class can't agree on what to get because everyone has a different idea. Eric and two of his friends, Jennifer and Tom, want to find out which piece of equipment is used most. They think that this will help the class to decide.

First, they go to the grade 1-3 recess. Jennifer counts the number of children using the swings. Tom counts the number of children using the slides. Eric counts the number of children using the monkey bars. Their data look like this.

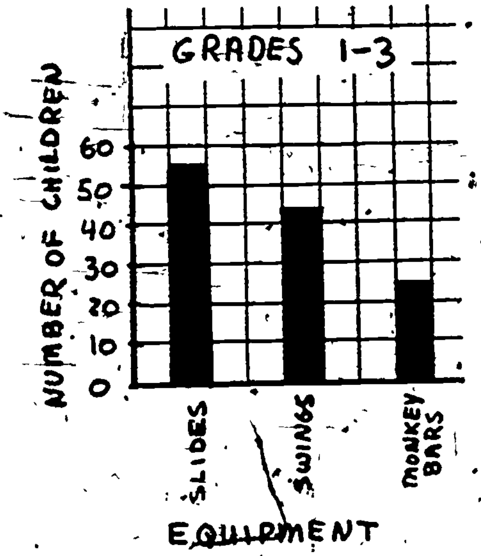
EQUIPMENT USED APRIL 2 (Grades 1-3)	
EQUIPMENT	NUMBER OF CHILDREN
Slides	55
Swings	42
Monkey Bars	24

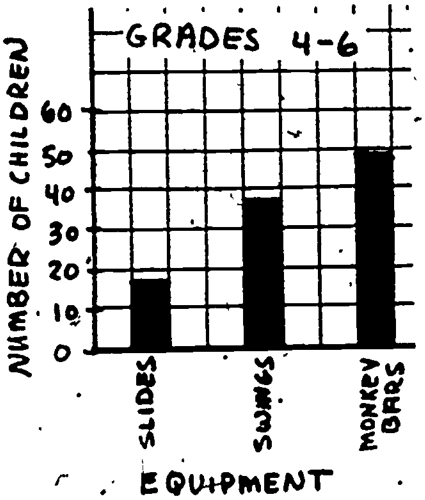


Then they go to the grade 4-6 recess and do the same thing. They count the number of children using the slides, swings, and monkey bars. The grade 4-6 list looks like this.

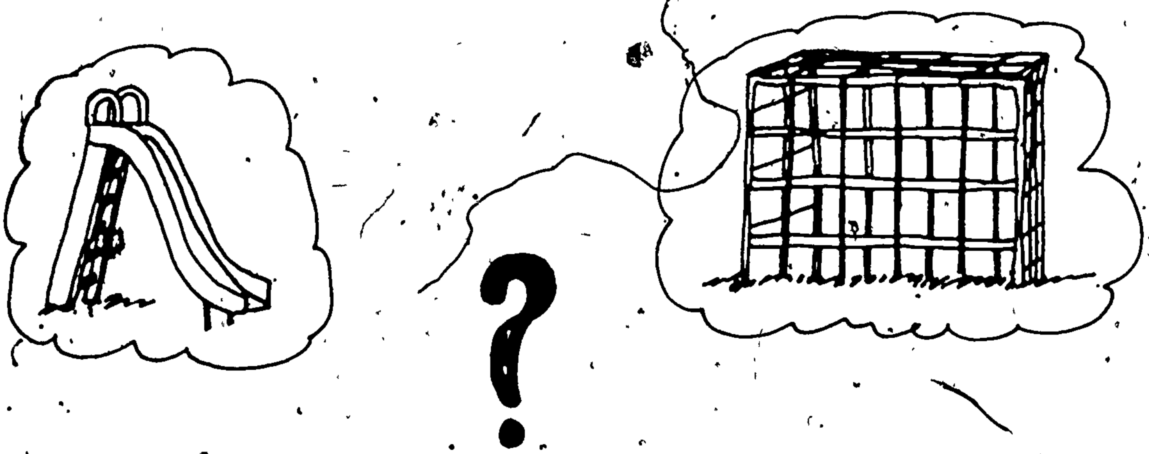
EQUIPMENT USED (Grades 4-6)	APRIL 2
EQUIPMENT	NUMBER OF CHILDREN
Slides	18
Swings	38
Monkey Bars	49

Eric, Tom, and Jennifer know what to do next. They make a bar graph for each set of data. The bar graphs look like this.

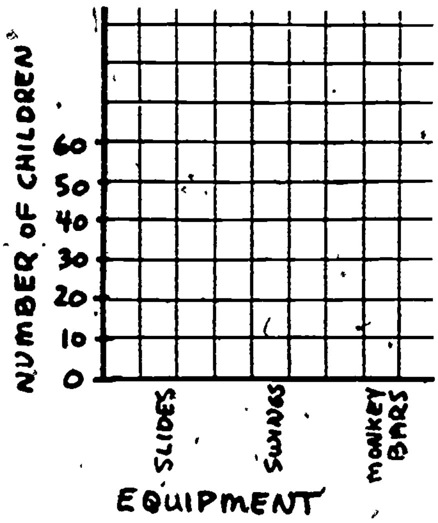




They look at the graphs. They see that grades 1-3 use the slides most, but that grades 4-6 use the monkey bars the most. "What should we do now?" asks Tom. "The different grades like different types of equipment. We still don't know which piece of equipment to buy."

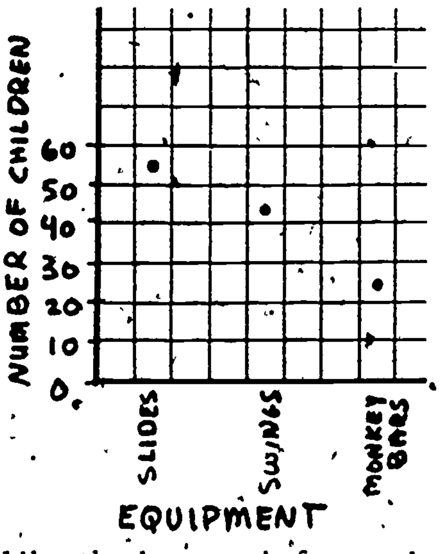


Eric has an idea. "We can make a line chart with our data. Maybe when we see our data on the line chart, it will help us to decide. We can use our bar graphs to make the line chart. We made the scales and labels on the two bar graphs the same; so a line chart will be easy to make." He puts the same scale and labels on another piece of graph paper. The graph looks like this.



"Now we can put marks on the graph showing where the tops of the bars for each bar graph go. We can use red dots to show where the tops of the bars go for grades 1-3, and green Xs to show where the tops of the bars go for grades 4-6. That way we can tell them apart."

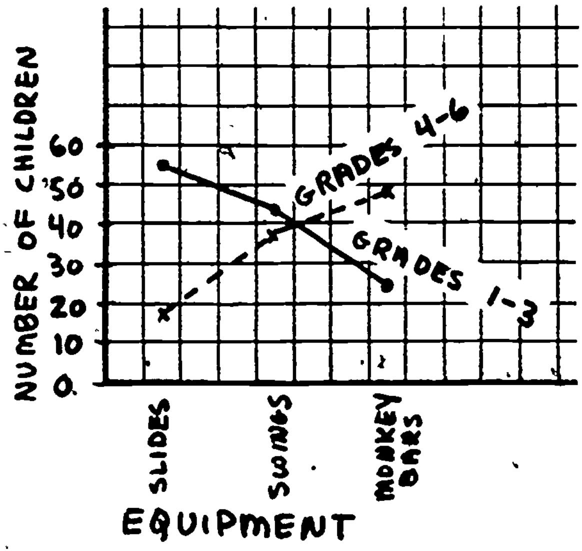
Eric puts the red dots first. He puts one dot at 55 in the middle of the column marked SLIDES. He puts another dot at 42 in the middle of the column marked SWINGS, and a third dot at 24 in the middle of the column marked MONKEY BARS. Now the graph looks like this.



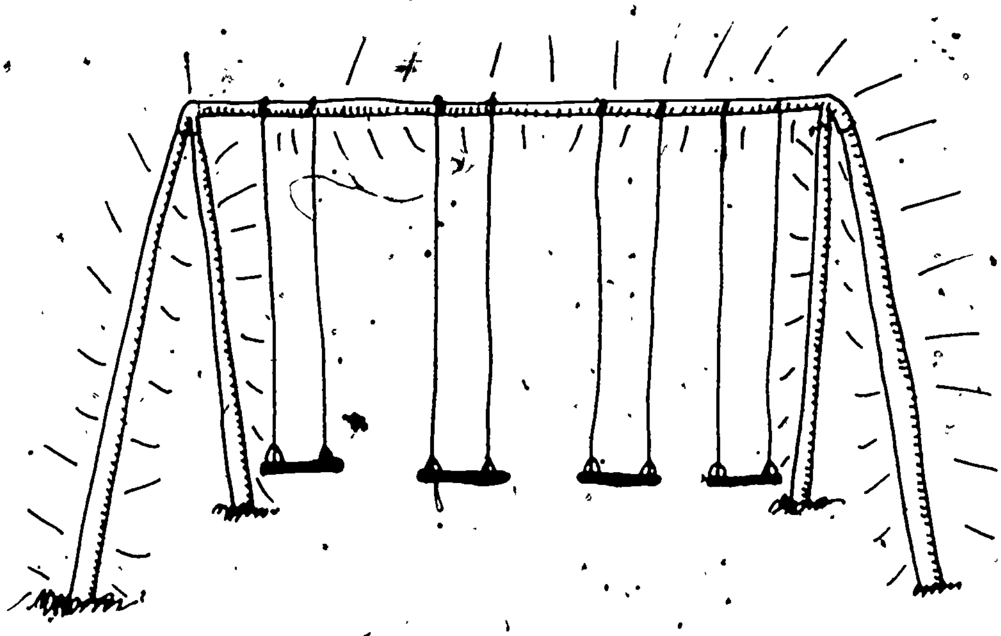
"This graph looks just like the bar graph for grades 1-3 with the bars melted away," says Tom. "Now I suppose we can put on the green Xs. May I do it?"

Tom puts on the green Xs. He puts a green X at 18 in the middle of the column marked SLIDES. Then he puts on the other two green Xs. "What do we do now?" he asks. "Are we finished?"

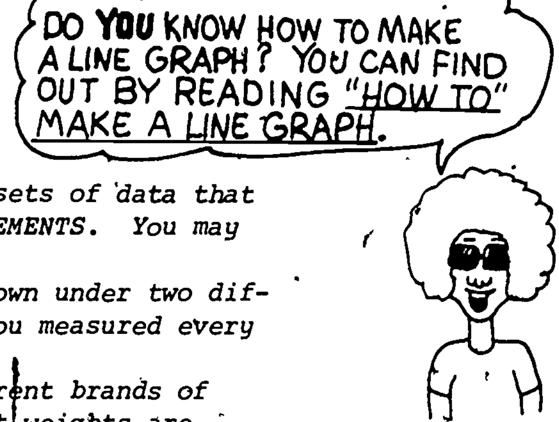
"There is just one more thing to do. We can connect each set of marks with lines," says Eric. "We can connect the red dots with a solid red line and the green Xs with a dashed green line. That will make the dots easier to see." Jennifer wants to help. She puts the lines on the graph. Then she labels each line. Now the line chart looks like this:



Jennifer looks at the finished line chart. "I think we should recommend swings," she says. "All grades use swings a lot." Eric, Tom, and Jennifer show the line chart to the class. They explain how they could tell from the graph that both groups use swings a lot even though both groups use something else more. They show the class that swings are the second-highest point on both lines. When the class votes, swings win, and so the class uses their money to buy swings.

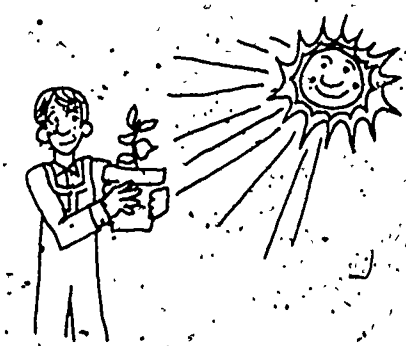


MAKING A DOUBLE LINE GRAPH



Maybe you have collected two sets of data that each have two kinds of MEASUREMENTS. You may want to compare

- *the heights of plants grown under two different conditions that you measured every week*
- *the lengths of two different brands of rubber bands as different weights are attached to them*
- *the hourly temperatures for two different days*



If you are comparing two groups of the same kind of MEASUREMENTS, taken over the same time period, you can put all of your data on a DOUBLE LINE GRAPH. Then it will be easy to compare how the two groups change or grow. You will be able to decide which group grows or changes more by looking at the graph.

In this story, three children use a double line graph to decide whether they should grow their plants in the sun or in the shade.

Lula, Patrice, and Jerome are growing coleus for a plant sale. They want the coleus to grow fast. All their plants are between 6 cm and 10 cm tall. Lula and Jerome want to put all of the plants in the sun but Patrice thinks that they will grow better in the shade. They decide to put six plants in the sun and six plants in the shade. They measure the six plants in each group every four or five days. Every time that they measure, they find the mean height of the plants in each group. After three weeks, their data look like this.

PLANTS IN SUN	
NUMBER OF DAYS	MEAN HEIGHT (cm)
0	7.7
7	8.2
12	9.0
16	9.6
21	10.5

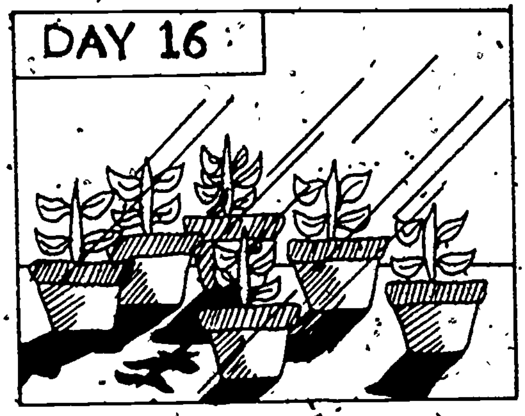
PLANTS IN SHADE	
NUMBER OF DAYS	MEAN HEIGHT (cm)
0	9.8
7	10.0
12	10.2
16	10.5
21	10.6

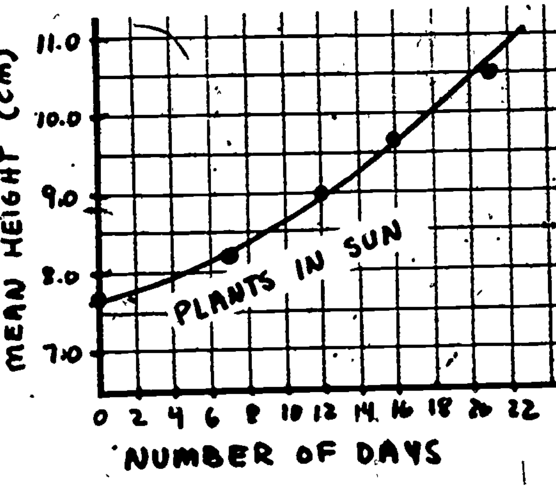
Lula, Patrice, and Jerome look at the data. They aren't sure which group grows faster. So they decide to make a graph. They think that a graph will make it easy to compare the two sets of data. But they aren't sure what kind of graph to make for their data.

Patrice says, "If we had only one of these sets of data, we could make a line graph because NUMBER OF DAYS and AVERAGE HEIGHT are both MEASUREMENTS. Should we make a double line graph?"

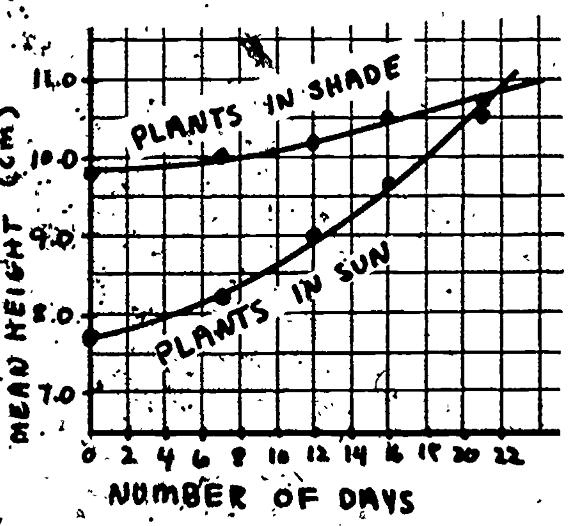
Jerome thinks this is a good idea. "Let's try it," he suggests.

The group makes a double line graph with their data. First they put on the graph the points for the plants in the sun. They draw a smooth line through or near those points. The graph looks like this.





Then they put on the graph the points for the plants in the shade. They draw a smooth line through or near those points. Now the graph is finished. It looks like this.



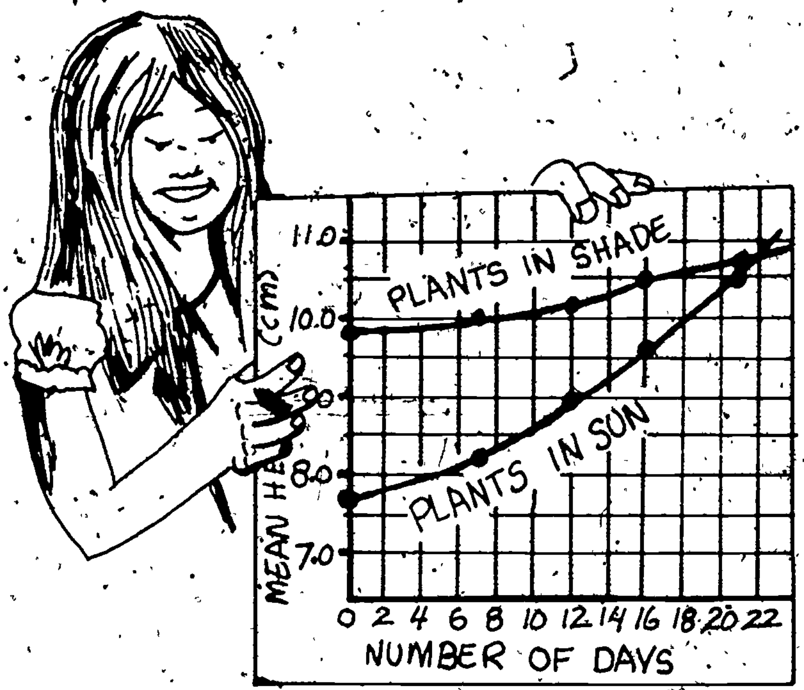
Lula, Jerome, and Patrice look at the graph. "Look!" says Lula. "The line for the plants in the shade is almost level. But the line for the plants in the sun is slanting up. It is steeper than the line for plants in the shade."

"Yes," says Jerome. "The plants in the sunlight are growing faster. They are getting taller. So the line is steep. The plants in the shade are hardly growing at all. Their line is almost level."

But Patrice is puzzled. "The line for plants in the shade started out higher. What does that mean?"

Lula knows. "When we put the plants in the groups, the plants we picked to put in the shade were taller than the plants we picked to put in the sun. So the line for plants in shade starts out higher than the line for plants in the sun. But the plants in the sun grew better anyway even though the plants in the shade had a head start."

Patrice looks at the graph again. "I learned a lot from this graph. I am going to show it to the rest of the class to prove that all of the coleus plants should be grown in the sun."



Jerome wonders whether their data really prove that coleus plants grow faster in the sun. "Maybe," he says, "the tall coleus plants just grow more slowly than the short plants." Then he checks by looking at the graph. "It looks like the plants in the sun kept growing faster even when they grew tall. But I am going to keep measuring the plants to see whether the plants in the sun keep growing fast when they get taller."

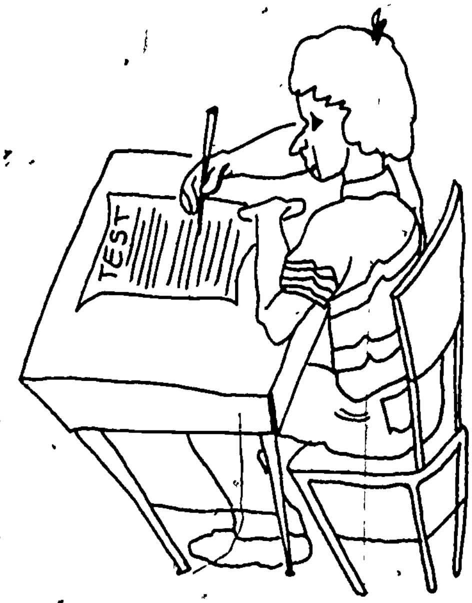
MAKING A DOUBLE HISTOGRAM

You may have collected two sets of data about the same things in two different places. You may have collected two sets of data about something before changes were made and after changes were made.

Your data may be two sets of the same type of NUMBER COUNTS and GROUPED MEASUREMENTS. Or your data may be all number counts. Your data may be two sets of the same type of NUMBER COUNTS and NUMBER COUNTS.

- *The data might be crossing times of students at two different intersections. These data are NUMBER COUNTS (number of students) and GROUPED MEASUREMENTS (crossing times).*
- *The data might be scores from spelling tests before studying the words by a new method and after studying the words. These data are NUMBER COUNTS (number of students with a given score) and NUMBER COUNTS (scores).*

If your data are like these, you can make a DOUBLE HISTOGRAM.



Looking at the pattern of the DOUBLE HISTOGRAM may help you decide how much difference there is between the two sets of data. That's what the students in this story find out.

Rita's class is trying to find out the best way to learn spelling words. The class has divided into groups to try different ways. Rita and her group, Clem and Tyrone, have collected two sets of data on scores from spelling tests. They want to see if playing the spelling game that they made up helped one group to spell better. Their data look like this.

SCORES BEFORE PLAYING GAME	SCORES AFTER PLAYING GAME
1, 1, 2, 2, 2, 3, 3, 3, 4, 4, 5	4, 5, 5, 5, 6, 6, 6, 6, 7, 7, 8

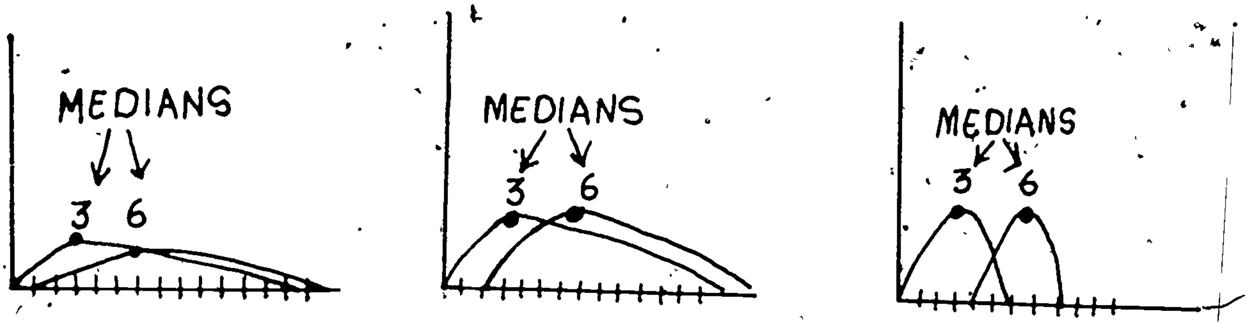
Clem finds the middle score, or the median score for each set of data. The medians are 3 for "before" scores and 6 for "after" scores.

Clem thinks that this proves that the spelling game is a good way to learn, but Rita and Tyrone disagree. They think the medians are really too close to tell.

Rita says, "If the medians were further apart, we could be sure. But 6 and 3 are only 3 apart."

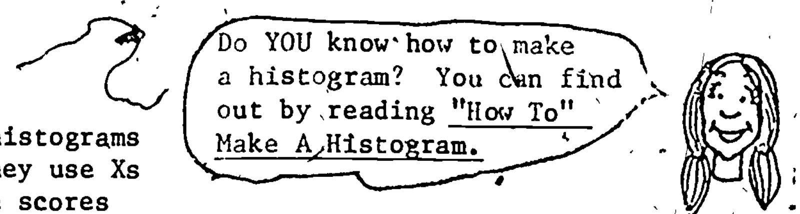
Tyrone says, "I know another way we can check the data to be sure! We can make histograms of our data. We can put the two histograms on the same graph. Then we can compare them with these pictures."

Tyrone draws three diagrams on the board to show the others what he means. The diagrams look like this.

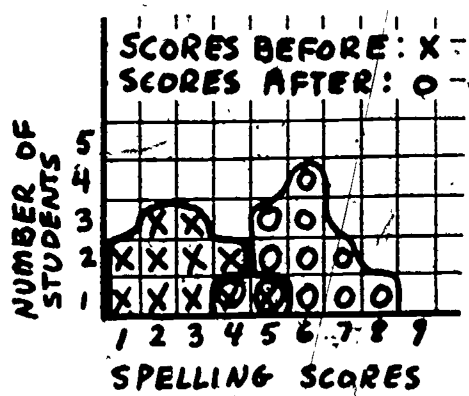


NO REAL CHANGE | DON'T KNOW | REAL CHANGE

Clem looks at the pictures. He says, "Now I see. These are pictures of histograms. When they are apart, they show a change. When they are almost together, they show there has been no change. When they are not too close or too far apart, then we can't tell from our data if there has been a change."



Clem, Rita, and Tyrone make two histograms of their data on the same graph. They use Xs for the scores before and Os for the scores after. When they are finished, the graph looks like this.



"The two histograms only overlap a little bit," says Rita.

Clem is happy. "Now we can say that our spelling game really did make an improvement in the group's spelling."

Rita's group thinks that they are finished. But just then Bill comes over to their group to ask for help. "We have some scores, too. Our medians are close. We don't know what to do."

Tyrone looks at the data from Bill's group. It looks like this.

SCORES BEFORE

1, 2, 2, 3, 3, 3, 4, 4, 5, 7, 8

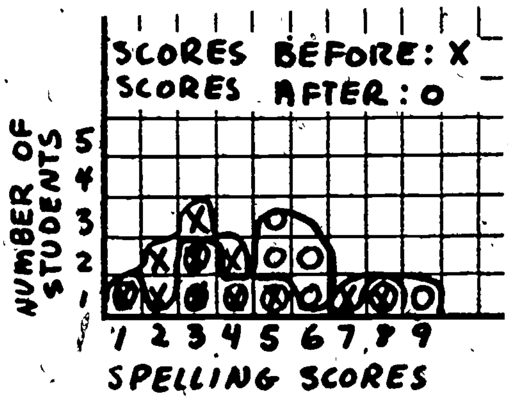
MEDIAN

SCORES AFTER

1, 3, 3, 4, 5, 5, 5, 6, 6, 8, 9

MEDIAN

The medians are 3 and 5. They are only 2 apart. Tyrone shows Bill's group how to make two histograms of their data on the same graph. The histograms look like this.

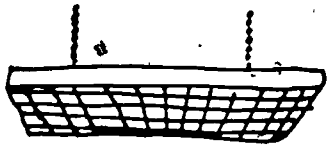


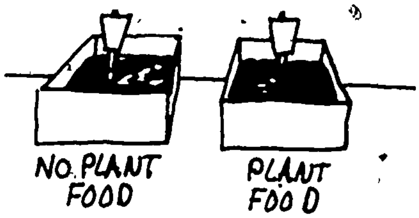
Bill's group is sad. The histograms don't tell them much. They are not too close or too far apart. The group can't tell whether there has been a change or not. Bill's group decides to start with some new spelling words and test their method again.

MAKING A Q-Q GRAPH

A q-q graph is a special kind of graph. You can use a q-q graph to compare data that you have collected from two different places or at two different times or of two different groups of things. You can make a q-q graph to compare two sets of NUMBER COUNTS of the same things taken under different conditions or to compare two sets of MEASUREMENTS of the same things taken under different conditions. You can use a q-q graph to compare these things:

- *the number of belts made by Room 202 and by Room 205 on several different days*
- *the speeds of cars at two different intersections*
- *the heights of plants grown with plant food and without plant food.*

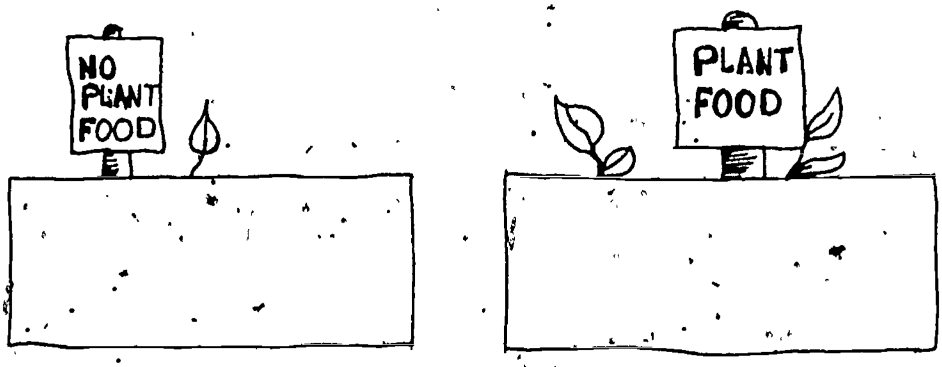




You can use a q-q graph to look at more than one thing about the data. It will help you see what is different about your sets of data. That's what Josette and her friends find out in this story.

Josette and her friends Randy and Carmen are planning to grow plants for a plant sale. Josette and Carmen want to buy plant food, but Randy thinks the plants will grow just as well without plant food. To settle the argument, Carmen suggests that they try an experiment. She thinks they should plant some seeds. Some of the seeds will get plant food and some will get no plant food. After the plants have come up, the group can measure the heights of the plants to see which way is better--plant food or no plant food.

Josette and Randy think that Carmen's idea is good. Josette plants 15 seeds in a box. She plans to give them 1 squirt of liquid plant food every day. Randy plants 15 seeds in a box, too. He waters his plants every day but does not give them any plant food. Randy and Josette put the boxes where they will get the same amount of light. They make sure they give the seeds the same amount of water. Then everyone waits.



About three weeks later, Carmen says that the plants look big enough to be measured. She measures the heights of the plants with no plant food. Two of the plants in the NO PLANT FOOD group didn't come up at all; so she writes two 0s for their heights. Then she measures the heights of the plants that got plant food. One of the plants in that group didn't come up either; so she lists its height as 0, too. The data look like this.

HEIGHTS OF PLANTS WITH NO PLANT FOOD (cm)

0, 0, 3, 2, 7.5, 6, 4.5, 5.5, 6, 5, 6.5, 7, 8, 2.5, 4

HEIGHTS OF PLANTS WITH PLANT FOOD (cm)

0, 0.5, 6, 8, 4, 7, 3, 10, 11, 6, 8, 5.5, 7.5, 5, 3

Josette knows what to do next. She puts the data in order from smallest to largest.

NO PLANT FOOD (cm): 0, 0, 2, 2.5, 3, 4, 4.5, 5, 5.5, 6, 6, 6.5, 7. 7.5, 8.

PLANT FOOD (cm): 0, 0.5, 3, 3, 4, 5, 5.5, 6, 6, 7, 7.5, 8, 8, 10, 11

Then she finds the median for each set of data.

NO PLANT FOOD (cm): ~~0~~, ~~0~~, ~~2~~, ~~2.5~~, ~~3~~, ~~4~~, ~~4.5~~, 5, ~~5.5~~, ~~6~~, ~~6~~, ~~6.5~~, ~~7~~, ~~7.5~~, ~~8~~

median

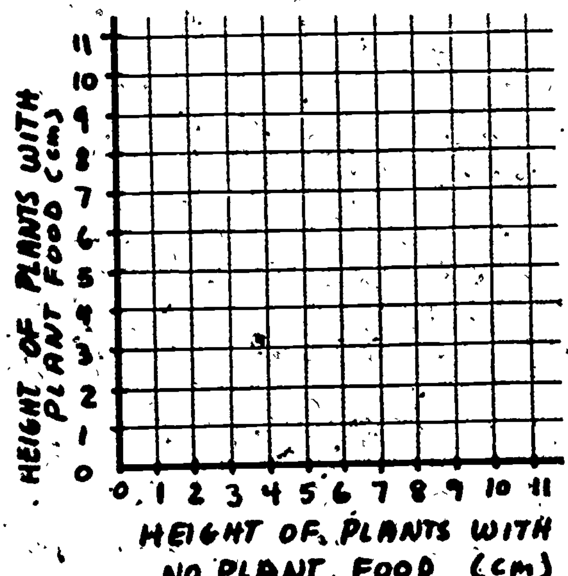
PLANT FOOD (cm): ~~0~~, ~~0.5~~, ~~3~~, ~~3~~, ~~4~~, ~~5~~, ~~5.5~~, 6, ~~6~~, ~~7~~, ~~7.5~~, ~~8~~, ~~8~~, ~~10~~, ~~11~~

median

Josette is disappointed. The median heights are close. She tells her friends, "It looks like the plants do just as well with no plant food as they do with plant food."

Randy smiles. "While we were waiting for the plants to get big enough to measure, I asked the teacher how to compare our data. We can make a q-q graph. If there is a difference, we will be able to tell.

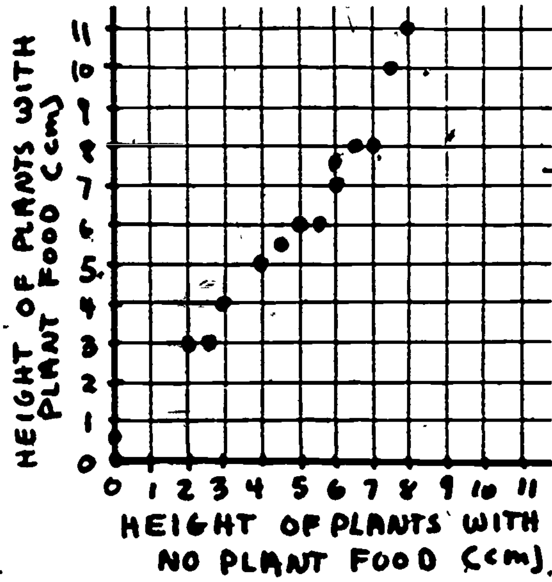
Randy draws two number lines on a piece of graph paper. He labels the horizontal axis HEIGHT OF PLANTS WITH NO PLANT FOOD, and the vertical axis HEIGHT OF PLANTS WITH PLANT FOOD. The graph looks like this.



Then Randy takes the two sets of data and lines them up next to each other so that the first numbers are matched, the second numbers are matched, and so forth. The data look like this.

NO PLANT FOOD	0	0	2	2.5	3	4	4.5	5	5.5	6	6	6.5	7	7.5	8
PLANT FOOD	0	0.5	3	3	4	5	5.5	6	6	7	7.5	8	8	10	11

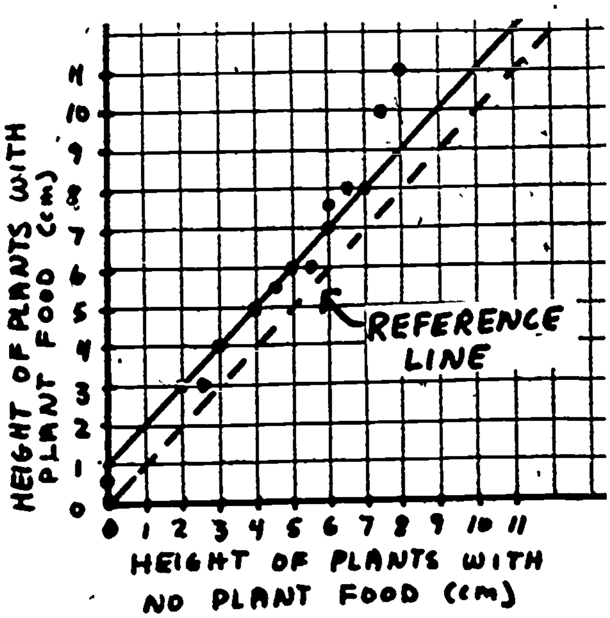
Randy plots the pairs of numbers on the graph paper. First he plots (0,0). Then he plots (0, 0.5). He plots all the pairs of points. Now the graph looks like this:



But Randy is not finished. He draws a dashed line through the points (0,0), (1,1), (2,2), (3,3), and so forth. He says, "This dashed line is called a REFERENCE LINE. It is what we would get if the two sets of data were exactly the same. We can compare our data with this line." Next he draws a solid line that goes through most of the points that show the data. The points that are not exactly on the line are close to the line. The graph looks like this.

"Well, what does it mean?" asks Josette.

Randy explains. "The solid line for the data is one space or one centimeter above the reference line. The solid line is parallel to the reference line, too. That space shows that not only are the medians one centimeter apart, but most of the plants (when we put them in ordered pairs) are one centimeter apart in height. Since the solid line is ABOVE the reference line by one centimeter, that means that most of the plants getting plant food are about one centimeter taller than the plants with no plant food. The plant food helps most of the plants the same amount."



"What if the line for the data were steeper?" asks Josette. "What would that mean?"

"It would mean that the plant food helps the bigger plants more than the smaller plants. The big plants getting plant food would be growing faster than the small plants getting plant food. It looks like that is happening anyway. The two points that are quite far above the solid line are the points for the taller plants."

Carmen looks at those points. "Maybe by the time the plants start to get big, they use up the food that is in the soil. Maybe that's when they really need the plant food. I think that we should get plant food."

Josette and Randy agree with Carmen. Josette says, "The plant food helps all the plants a little bit. It helps the bigger plants more than the smaller plants. We should buy plant food and give it to all the plants that are taller than 6 centimeters."

MAKING A SCATTER GRAPH

Sometimes you may collect two different kinds of data about the same things.

- *You might measure the heights of all of your plants and also count their leaves.*
- *You may have listed how many children in each grade have a bike and how many ride their bikes to school.*

You may want to find out if your two sets of data are *__related__*.

- *You may wonder whether a tall plant has more leaves than a short plant.*
- *You may guess that grades where more children have a bike are the grades where more children ride their bikes to school.*

But you aren't sure. How can you find out? You can make a SCATTER GRAPH of your data to find out. The SCATTER GRAPH WILL SHOW YOU WHETHER THE DATA ARE RELATED. The SCATTER GRAPH will show you whether your guess is right.

In this story, the children want to find out whether the foods that are thrown out the most in the lunchroom are the foods that most children don't like. They find out by making a scatter graph.

Ricky's class wants to improve the food served in the lunchroom. Ricky, Dana, Michelle, and Peggy are working in a group to find out which foods the students throw out and which foods the students dislike. They have already done a lot. They have collected data about each food served in the lunchroom in these two ways:

__The First Way: Which foods are thrown out__? Each day Ricky counted the number of lunches bought that day. Dana, Michelle, and Peggy took turns counting the number of portions of different foods thrown out. Since different numbers of lunches were bought each day, Ricky and Dana divided the number of portions of each different food wasted by the total number of lunches bought for that day. Then they multiplied their answers by 100% to get the percentage of each kind of food wasted that day.

Their calculations for one day look like this.

NUMBER OF PORTIONS WASTED / TOTAL NUMBER OF LUNCHES	=	FRACTIONAL AMOUNT OF FOOD WASTED	and	FRACTION OF FOOD WASTED x 100%	=	% OF FOOD WASTED
Spaghetti Wasted / Number of Lunches = 93/310	=	.30	and	.30 x 100%	=	30%
Salad Wasted / Number of Lunches = 81/310	=	.26	and	.26 x 100%	=	26%
Ice Cream Wasted / Number of Lunches = 22/310	=	.07	and	.07 x 100%	=	7%

Then they put their data in a table. Their data for two weeks look like this.

FOOD	PERCENTAGE WASTED (%)	FOOD	PERCENTAGE WASTED (%)
Pizza	12	Salad	26
Fish	38	Boiled Potatoes	60
Chicken	17	Lima Beans	77
Meatloaf	47	String Beans	37
Spaghetti	30	Beets	68
Tuna Casserole	72	Baked Beans	48
Hot Dogs	12	Corn	27
Stew	76	Jello	22
Hamburger	9	Ice Cream	7
Soup	40	Cookies	5
Peas	63	Fruit	20
French Fries	21	Cake	8
Cole Slaw	52		

The Second Way: Which foods do students dislike? Peggy and Michelle surveyed the other children in the school to find out what foods students dislike. Then they tallied the data and found a percentage, too. They found the percentage of students who said they disliked a certain food. Their data look like this.

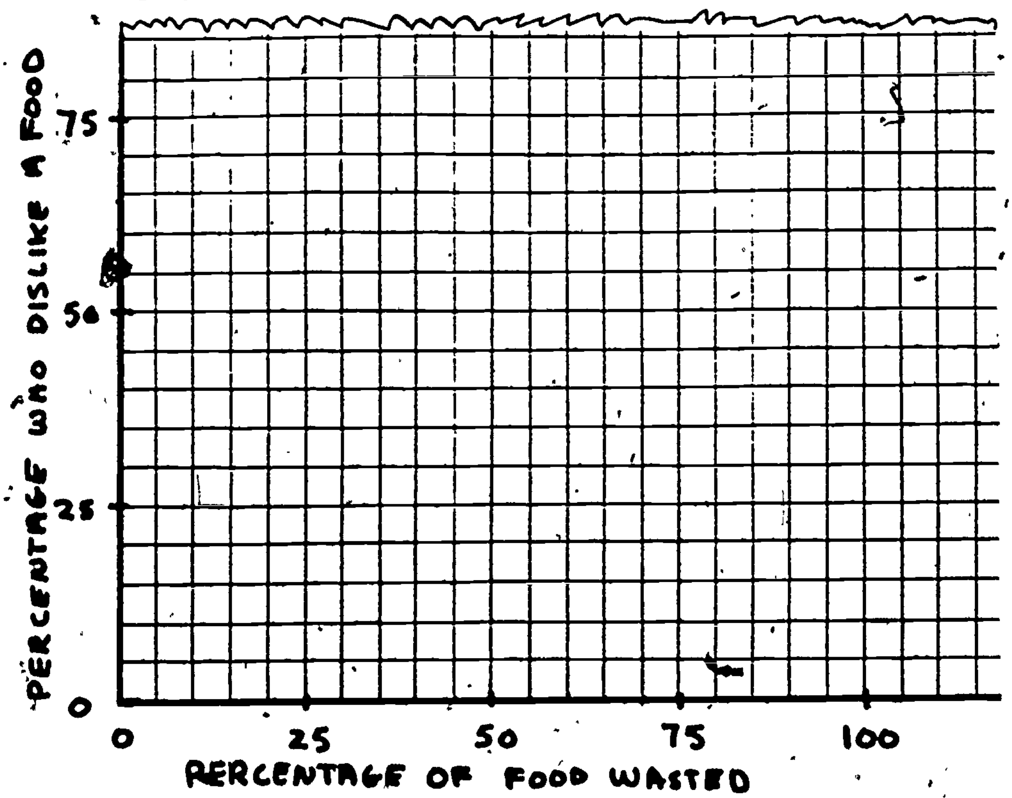
FOOD	PERCENTAGE WHO DON'T LIKE IT (%)	FOOD	PERCENTAGE WHO DON'T LIKE IT (%)
Pizza	32	Salad	48
Fish	52	Boiled Potatoes	71
Chicken	23	Lima Beans	81
Meatloaf	43	String Beans	40
Spaghetti	38	Beets	84
Tuna Casserole	68	Baked Beans	62
Hot Dogs	17	Corn	19
Stew	82	Jello	46
Hamburger	12	Ice Cream	10
Soup	42	Cookies	4
Peas	51	Fruit	52
French Fries	25	Cake	11
Cole Slaw	60		

Now the group wants to compare the two sets of data to find out whether the foods that are thrown out are the same as the foods that are disliked. They want to compare two things about each kind of food: how much is wasted and how many children say they don't like it. They want to look at both of these things at the same time. They need to make a graph.

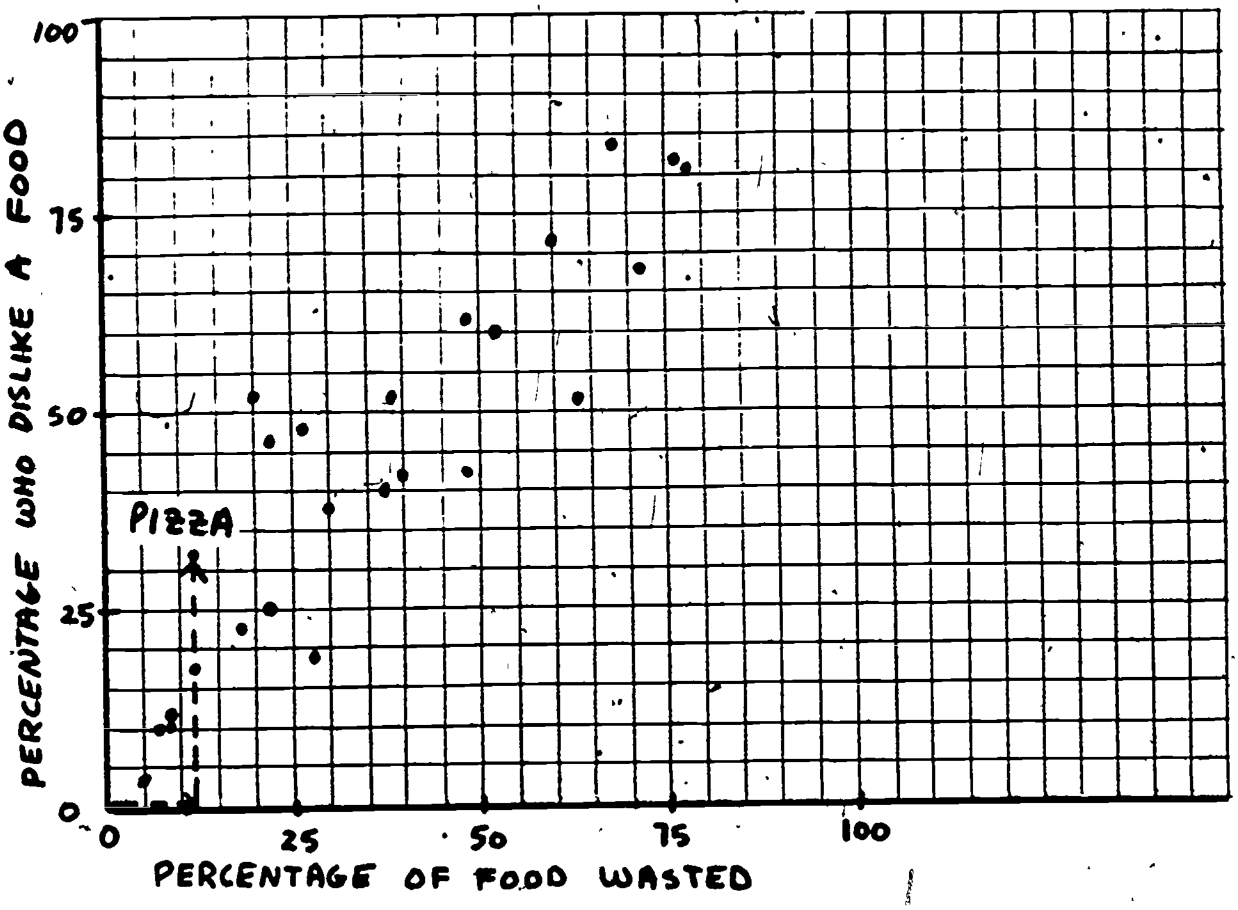
The group talks about what kind of graph they should make. They know that they have two kinds of data about the same things; so they decide to make a scatter graph. First they make a combined data chart. It looks like this.

FOOD	PERCENTAGE WASTED (%)	PERCENTAGE WHO DON'T LIKE IT (%)	FOOD	PERCENTAGE WASTED (%)	PERCENTAGE WHO DON'T LIKE IT (%)
Pizza	12	32	Salad	26	48
Fish	38	52	Boiled Potatoes	60	71
Chicken	17	23	Lima Beans	77	81
Meatloaf	47	43	String Beans	37	40
Spaghetti	30	38	Beets	68	84
Tuna Casserole	72	68	Baked Beans	48	62
Hot Dogs	12	17	Corn	27	19
Stew	76	82	Jello	22	46
Hamburger	9	12	Ice Cream	7	10
Soup	40	42	Cookies	5	4
Peas	63	51	Fruit	20	52
French Fries	21	25	Cake	8	11
Cole Slaw	52	60			

Then they get some graph paper. They draw two number lines on the graph paper. They label the horizontal line PERCENTAGE OF FOOD WASTED and the vertical line PERCENTAGE WHO DISLIKE A FOOD. Then they put on the scales. They know that percentage goes from 0% to 100%, so they number each line by 25s up to 100%. The graph looks like this.



Now they must put the points on the graph. For each food, they put a point on the graph that shows the percentage of that food wasted and the percentage of children who don't like that food. To put the point for pizza on the graph, they count over 12 to the right and then count up to 32. They put all of the points on the graph this way. When they finish, the graph looks like this.



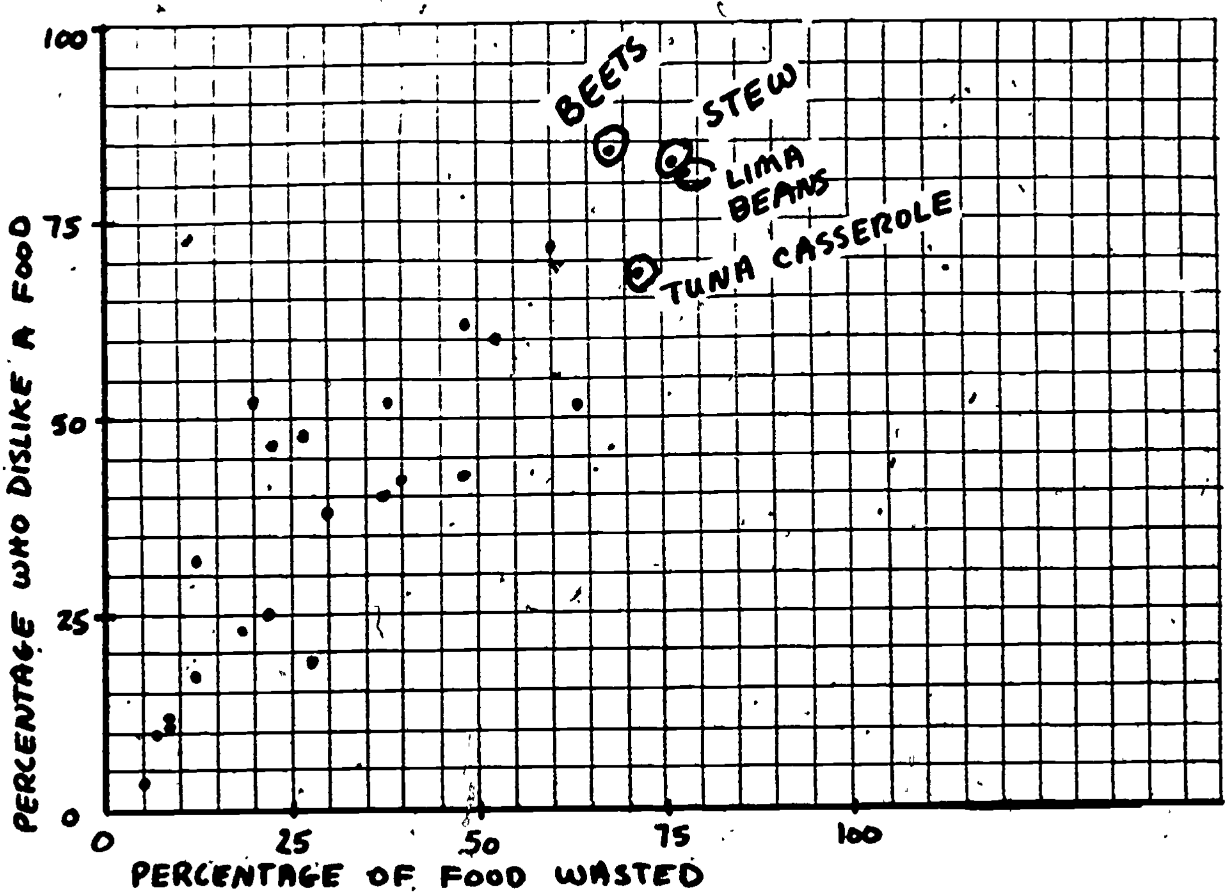
The children look at the finished graph. They notice several things. "Most of the points are going from the lower left corner of the graph up to the upper right corner. They are making a pattern," says Peggy.

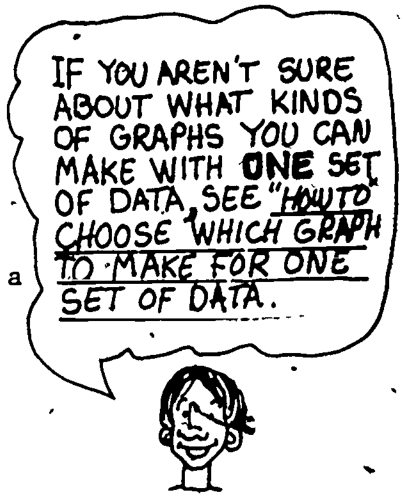
"Yes," says Michelle. "The foods that <u>aren't</u> thrown out much are the ones that <u>few</u> students say they don't like and the foods that <u>are</u> thrown out a lot are the ones that <u>many</u> students say they don't like."

Dana is interested in another thing about the graph. "I can see that each point stands for a certain food. All we have to do to find the foods that are thrown out the most <u>and</u> the foods that most students say they don't like is to look at the points in the upper right corner of the graph and see which foods these points stand for."

Peggy looks at the points in the top right corner of the graph. "Look," she says, "tuna casserole, stew, lima beans, and beets were the most thrown out and the most disliked. We should ask the cook to stop serving those foods." She draws circles around all those points so that the others can see them.

Now the graph looks like this. The group decides that they will take the graph to the cook and show it to her when they ask her to stop serving those foods.





HOW TO PICK A GRAPH FOR YOUR DATA

Look at ONE SET of your data--it doesn't matter which one.

Can you make a BAR GRAPH from it? If so, you may want to make a LINE CHART for both sets. Your two sets of data may be

- Number of students vs. Playground Equipment Preferred for Grades 1-3 and Grades 4-6
- Number of Cars vs. Days of the Week for Morning and Afternoon
- Number of Seeds Stored vs. Days of the Week for Your Pet Hamster and Your Pet Gerbil.

Can you make a LINE GRAPH from one set of your data? If so, you may want to make a DOUBLE LINE GRAPH for both sets. Your two sets of data may be

- Average Height vs. Number of Days for Plants in Sun and Plants in Shade
- Temperature vs. Time of Day for Monday and Tuesday
- Length vs. Weight for Two Different Brands of Rubber Bands.

Can you make a HISTOGRAM from one set of your data? If so, you may want to make a DOUBLE HISTOGRAM or a Q-Q GRAPH for both sets. Your two sets of data may be

- Number of Students vs. Spelling Scores (in groups) for Before and After
- Number of Plants vs. Heights of Plants (in groups) for Plant Food and No Plant Food
- Number of Students vs. Crossing Times (in groups) for Oak Street Intersection and Main Street Intersection.

If NONE of these apply to YOUR data, look at BOTH sets of your data. Do you have two different MEASUREMENTS or NUMBER COUNTS of the same thing for a whole group of things? Then you may want to make a SCATTER GRAPH. Your two sets of data may be

- Percentage of a Food Wasted vs. Percentage of Students Disliking that Food for Many Foods
- Height of a Plant vs. Number of Leaves That Plant Has for Many Plants
- Height of a Student vs. Weight of That Student for Many Students.

If the graph that you choose doesn't tell you what you want to know, then you may need to REORGANIZE your data. That may help you to draw a different graph that will tell you what you want to know.