Skills References

Contents

Safety Symbols

Safety symbols identify potential hazards. When you see any of the following symbols, either in this book or on a product, take extra care.

Safety Symbols in This Book

Some activities in this book have symbols to help you conduct the activity safely. Look for these symbols at the beginning of activities.


When you see this symbol, wear goggles or safety glasses while doing the activity.


This symbol tells you that you will be using glassware during the activity. Take extra care when handling it.


When you see this symbol, wear an apron while doing the activity.


When you see this symbol, wear insulated gloves to protect your hands from heat.


This symbol tells you that you will be working with sharp objects. Take extra care when handling them.


When you see this symbol, wear gloves while doing the activity.


This symbol tells you that you will be working with wires and power sources. Take extra care when handling them.


This symbol tells you that you will be working with fire. Make sure to tie back loose hair. Take extra care around flames.

WHMIS Symbols

Here are symbols you might see on the materials you use in your classroom. You will see them occasionally in the Materials and Equipment lists for activities when a substance that needs a warning is used. These symbols are called Workplace Hazardous Materials Information System (WHMIS) symbols. They are placed on hazardous materials used at job sites and in science classrooms. They may also be on other manufactured products bought for home use. A container may have one or more of the symbols shown below.


compressed gas


biohazardous infectious material


dangerously reactive material


corrosive material


oxidizing material


flammable and combustible material


poisonous and infectious causing immediate and serious toxic effects


poisonous and infectious causing other toxic effects

Hazard Symbols for Home Products

You have probably seen some of these hazard symbols on products at home. They are a warning that the products can be harmful or dangerous if handled improperly. These hazard symbols have two shapes: a triangle or an octagon. A triangle means that the container is dangerous. An octagon means that the contents of the container are dangerous. Here are four of the most common symbols.


Flammable Hazard: The product could ignite (catch on fire) if exposed to flames, sparks, friction, or even heat.


Toxic Hazard: The product is very poisonous and could have immediate and serious effects, including death, if eaten or drunk. Smelling or tasting some products can also cause serious harm.

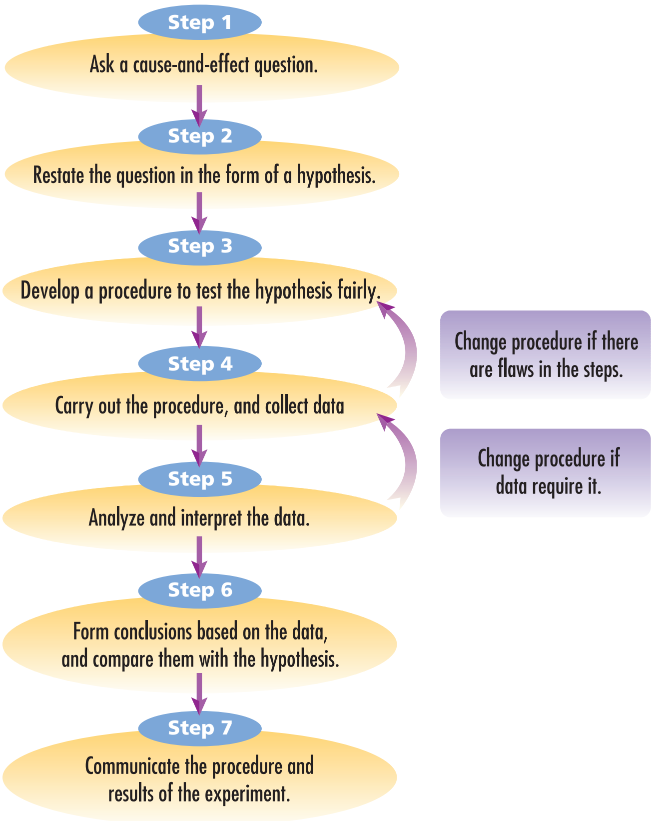

Corrosive Hazard: The product will corrode clothing, skin, or other materials and will burn eyes on contact.


Explosive Hazard: The container can explode if it is heated or punctured.

The Inquiry Process of Science

Scientists are always asking a lot of questions. They are always inquiring. They want to understand why the things they observe, and wonder about, happen. Experiments are important tools that scientists use to help them answer their questions.

When scientists plan experiments, they usually follow a simple set of steps.



Hint

Answers may lead to additional questions. New questions often lead to new hypotheses and experiments. Don't be afraid to ask questions, or to rethink the ones you've already asked.

STEP 1 Ask a cause-and-effect question.

Asking questions is easy. Asking questions that lead to reliable answers is more challenging. That's the reason scientists usually ask cause-and-effect questions. Here are a few examples.

- How does the concentration of laundry detergent in wash water affect the cleanliness of clothing?
- How do different temperatures affect the growth of seedlings?
- How does the amount of moisture affect the growth of mould on bread?

Notice how the causes — the detergent, temperature, and moisture — are things that are changeable. For example, you can have different concentrations of detergent, different temperatures, and different amounts of moisture. Causes are manipulated, usually called independent variables. They are factors that you change when you investigate a cause-and-effect question.

The results are changeable, too. For example, some clothes may become cleaner than others or not clean at all. Some seedlings may grow better than others or some might not grow at all. Some bread samples may have lots of mould, some may have less, and some might not have any. Results are responding variables usually called dependent variables. They change because of the independent variable.

When you ask a cause-and-effect question, you should include only one independent variable in your question. This allows you to see the effect of that variable on the dependent variable.

STEP 2 Restate the question in the form of a hypothesis.

A hypothesis is a way of restating a cause-and-effect question so that it gives a reasonable, possible answer. Basically, a hypothesis is an intelligent guess at the solution to a problem or question. It is usually in the form of an "If ... then" statement and states the relationship between the independent and dependent variables.

Here are hypotheses for the questions outlined in Step 1.

- If the concentration of the detergent is high, then clothing will become cleaner.
- If the temperature is decreased, then the seedlings will not grow as well.
- If the amount of moisture is increased, then the bread will get mouldier.

Hint

A hypothesis is an early step in the experiment-planning process. Your hypothesis can turn out to be "right," but it doesn't always. That's what the experiment is for — to test the hypothesis.

STEP 3 Develop a procedure to test the hypothesis fairly.

When you develop a procedure, you need to ask yourself some questions. Your answers to these questions will help you plan a fair and safe experiment. Here are some questions you should think about. These questions are answered for the seedling experiment.

- **Which independent variable do you want to investigate?** The independent variable is temperature.
- **How will you measure this variable (if it is measurable)?** You can measure temperature with a thermometer.
- **How will you keep all other variables constant (the same) so they don't affect your results?** In other words, how will you control your experiment so it is a fair test? To control the experiment, these variables should be kept constant: the amount of light the seedlings receive; the amount and temperature of water applied to the seedlings; the kind of soil the seedlings are planted in.
- **What materials and equipment will you need for the experiment?** The materials would include seedlings, soil, growing pots or containers (same size), water and a watering can, a light source, a thermometer, and a ruler or other measuring device.
- **How will you conduct the experiment safely?** What safety factors should you consider? Some of the safety factors to consider include putting the seedling pots in a place where they would not be disturbed, washing your hands after handling the materials, and making sure you don't have any allergies to the soil or seedlings you use.
- **How will you set up the procedure to get the data you need to test your hypothesis?** You could divide your seedlings into groups (e.g., three seedlings for each temperature) and grow each group at a certain temperature. You would keep track of how much each seedling in a group grew over a specified amount of time (e.g., four weeks) and calculate the average for the group.

STEP 4 Carry out the procedure, and collect data.

Depending on the kind of experiment you have planned, you may choose to record the data you collect in the form of a chart or table, a labelled sketch, notes, or a combination of these. For example, a good way to record the seedling data would be in a table (one for each week of the experiment).

Week 1: Height of Seedlings Grown at Different Temperatures

Temperature seedlings grown at (°C)	Height of seedling 1 (cm)	Height of seedling 2 (cm)	Height of seedling 3 (cm)	Average height (cm)
20				
15				
10				

Hint

Analyzing the data you collect is the only way you have to assess your hypothesis. It's important that your record keeping be organized and neat.

STEP 5 Analyze and interpret the data.

Scientists look for patterns and relationships in their data. Often, making a graph can help them see patterns and relationships more easily. (Refer to Skills Reference 9 for more about graphing.)

A graph of the seedling data would show you if there is a relationship between temperature and growth rate.

Hint

If you have access to a computer, find out if it has the software to help you make charts or graphs.

Sources of Error

Analysis of the results usually includes the sources of error. One source of error is the variation that always occurs when an experiment is repeated, even though the experimenter follows a well-designed procedure carefully and works with properly functioning equipment. This error is mainly due to the limits in the precision (reproducibility) of the particular instrument used to take the measurements and in its readability. Scientists always repeat an experiment several times, which helps to reduce the effect of this source of error. In the science classroom, you may not always be able to repeat your experiment. However, you can get a sense of the accuracy of your results by comparing your data with those of your classmates or with theoretical values.

Another source of error can occur when a measuring instrument has not been properly calibrated. Calibration is the process of comparing the measurements given by the instrument against known standards and ensuring that the two values match. If an instrument is not properly calibrated, the measurements taken with that instrument will always contain an error. Professional scientists therefore calibrate their instruments regularly. These sources of error can be avoided.

Finally, error may result if there is a flaw in the design of the experiment or in how the procedure was carried out. When an experiment is affected by this source of error, the relationship between the independent and dependent variables will be unclear. If this occurs, re-examine the procedure and ensure that there were no unidentified variables that may have affected the results.

STEP 6 Form conclusions based on the data, and compare them with the hypothesis.

Usually, forming a conclusion is fairly straightforward. Either your data will support your hypothesis or they won't. Either way, however, you aren't finished answering your cause-and-effect question.

For example, if the seedlings did not grow as well in cooler temperatures, you can conclude that your data support your hypothesis. But you will still need to repeat your experiment several times to see if you get the same results over and over again. Doing your experiment successfully many times is the only way you and other scientists can have faith in your data and your conclusions.

If your data don't support your hypothesis, there are two possible reasons why.

- Perhaps your experimental plan was flawed and needs to be reassessed and possibly planned again.
- Perhaps your hypothesis was incorrect and needs to be reassessed and modified.

For example, if the seedlings grew better in the lower temperatures, you would have to rethink your hypothesis or look at your experiment for flaws. You would need to ask questions to help you evaluate and change either your hypothesis or plan. For example, you could ask: Do certain seedlings grow better at lower temperatures than others? Do different types of soil have more of an effect on growth than temperature?

Every experiment is different and will result in its own set of questions and conclusions.

STEP 7 Communicate the procedure and results of the experiment.

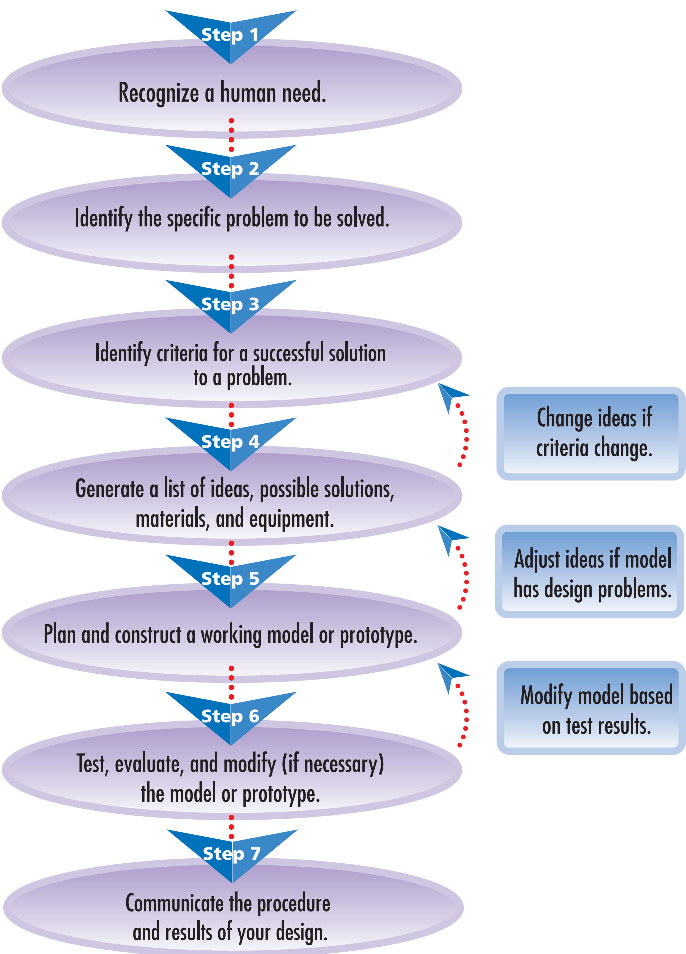
Scientists always share the results of their experiments with other people. They do this by summarizing how they performed the first six steps. Sometimes, they will write out a formal report stating their purpose, hypothesis, procedure, observations, and conclusions. Other times, they share their experimental results verbally, using drawings, charts, or graphs. (See Skills References 6 and 9 for help on how to prepare your results.)

When you have finished your experiment, ask your teacher how he or she would like you to prepare your results so you can share them with the other students in your class.

The Problem-Solving Process for Technological Development

When you plan an experiment to answer a cause-and-effect question, you follow an orderly set of steps. The same is true for designing a model or prototype that solves a practical problem.

When people try to solve practical problems, they usually follow a simple set of steps.



STEP 1 Recognize a human need.

This involves recognizing what the problem is. For example, suppose you observe that a rope bridge across a ravine at a local park is very unstable and swings back and forth when crossed. You find that most people are not comfortable crossing the bridge and don't get to enjoy one of the nicer areas of the park. You wish there were a way to make the bridge more stable so more people would use it. That is the situation or context of the problem.

STEP 2 Identify the specific problem to be solved.

When you understand a situation, you can then define the problem more exactly. This means identifying a specific task to carry out. In the situation with the bridge, the task might be to build a new bridge or add support to the existing bridge.

STEP 3 Identify criteria for a successful solution to a problem.

You have defined the problem but before you start looking for solutions, you need to establish your criteria for determining what a successful solution will be.

One of your criteria for success in the bridge example would be the completion of a stable bridge. The criteria you choose do not depend on which solution you select — whether to reinforce the old bridge or build a new bridge. In this case, whatever the solution, it must result in a stable bridge.

When you are setting your criteria for success, you must consider limits to your possible solutions. For example, the bridge may have to be built within a certain time, so rebuilding completely may not be possible. Other limitations could include availability of materials, cost, number of workers needed, and safety.

If you are building a product or device for yourself, you may set the criteria for success and the limitations yourself. In class, your teacher will usually outline them.

Hint

Always consider safety. This includes safe handling and use of materials and equipment, as well as being aware of possible environmental impacts of your ideas. Discuss with your teacher and fellow students how your solution might affect the environment.

STEP 4 Generate a list of ideas, possible solutions, materials, and equipment.

Brainstorming and conducting research are key components of this step. When you brainstorm, remember to relax and let your imagination go. Brainstorming is all about generating as many ideas as possible without judging them. Record your ideas in the form of words, mind maps, sketches — whatever helps you best.

Conducting research may involve reading books and magazines, searching the Internet, interviewing people, or visiting stores. It all depends on what you are going to design.

One idea for the rope bridge would be to anchor the bridge with strong rope or thick metal wire to large rocks or to the hillside at either end of the bridge. Sketches and diagrams would help to generate different ideas for the bridge design.

Hint

Humans have been inventors for tens of thousands of years — so take advantage of what has already been developed. When you're solving a problem, see how others have solved the same problem before and use their efforts as inspiration. You can also look for ways to improve on their ideas.

STEP 5 Plan and construct a working model or prototype.

Choose one possible solution to develop. Start by making a list of the materials and equipment you will use. Then, make a working diagram, or series of diagrams, on paper. This lets you explore and troubleshoot your ideas early on. Your labels should be detailed enough so that other people could build your design. Show your plans to your teacher before you begin construction work.

A simple model of the bridge could be made to show how and where components such as stabilizing wires could be added.

Hint

If things aren't working as you planned or imagined, be prepared to modify your plans as you construct your model or prototype.

STEP 6 Test, evaluate, and modify (if necessary) the model or prototype.

Testing lets you see how well your solution works. Testing also lets you know if you need to make modifications. Does your model or prototype meet all the established criteria? Does it solve the problem you designed it for?

Invite your classmates to try your product. Their feedback can help you decide what is and isn't working and how to fix anything that needs fixing. Perhaps the stabilizing wires on the bridge model could be anchored elsewhere. Maybe more wires could be added.

Hint

For every successful invention or product, there are thousands of unsuccessful ones. Sometimes, it's better to start over from scratch than to follow a design that doesn't meet its performance criteria.

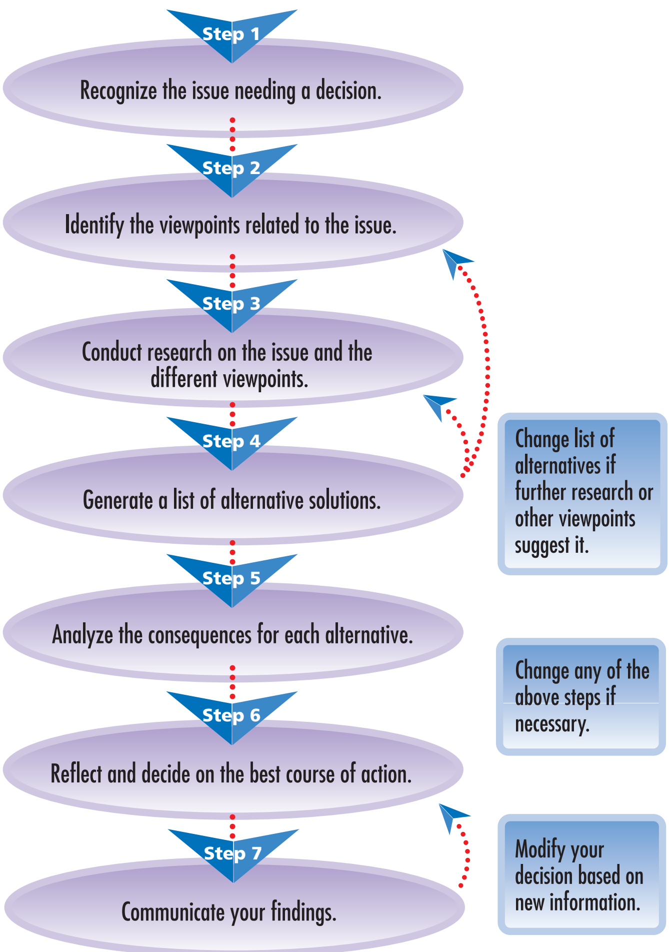
STEP 7 Communicate the procedure and results of your design.

Inventors and engineers create things to meet people's needs. When they make something new, they like to show it to other people and explain to them how it works. Sometimes, they will use a carefully drawn diagram of the new device and write about how they performed the first six steps. Other times, they will show the device to people and explain verbally how it works and how they built it. Your teacher will tell you how to prepare your results so you can exhibit the new device you make.

The Decision-Making Process for Social and Environmental Issues

People can have many different viewpoints or perspectives about social and environmental issues. This usually means that an issue has more than one possible solution. Scientific and technological information can be used to increase our understanding of an issue and help resolve it.

When people try to make a decision or reach a consensus about an issue, they need to use a decision-making process. Here are the steps in one possible process.



STEP 1 Recognize the issue needing a decision.

This involves recognizing that an issue exists. An issue is a controversy that needs to be resolved. It may have more than one possible solution, but the chosen one is usually the one that satisfies the most people. For example, suppose you and your friends want to have some trees in a public park cut down in order to make space for a playing field. Some members of your community feel that the trees should be preserved for the birds that nest there. The local environmental specialist says that when it rains, the trees protect a nearby stream by reducing run-off, so they should be left standing. Other people say that your idea of building a playing field is too expensive.

STEP 2 Identify the viewpoints related to the issue.

The viewpoints expressed in the example in Step 1 are recreational, ecological, and economic.

People often evaluate issues using one or more viewpoints. Some of these viewpoints are:

Different Viewpoints

Viewpoints	Interested in
Cultural	Customs and practices of a particular group of people
Ecological	Protection of the natural environment
Economic	Financial aspects of the situation
Educational	Acquiring and sharing knowledge and skills
Esthetical	Beauty of art and nature
Ethical	Beliefs about what is right and wrong
Health and safety	Physical and mental well-being
Historical	Knowledge in dealing with past events
Political	Effect of the issues on governments, politicians, political parties
Recreational	Leisure activities
Scientific	Knowledge based on the inquiry process of science
Social	Human relationships, public welfare, or society
Technological	Design and use of tools and processes that solve practical problems to satisfy people's wants and needs

STEP 3 Conduct research on the issue and the different viewpoints.

You will be able to suggest an appropriate solution to an issue only if you understand the issue and the different viewpoints. It's important to gather unbiased information about the issue itself and then consider the information provided by people with different viewpoints.

Develop specific questions that will help to guide your research. Questions for the playing field issue might be:

- How many people will use the playing field?
- Is there another more suitable site for the playing field?
- What kind of birds nest in these trees? Could they nest elsewhere in the area?
- What is run-off, and why is it a problem?
- What would be the full cost of building the playing field (including the cost of removing the trees)?

Conducting research may involve interviewing people, reading books and magazines, searching the Internet, or making a field trip. It is important to evaluate your sources of information to determine if there is a bias and to separate fact from opinion. In this step, you are trying to gain a better understanding of the background of the issue, the viewpoints of different groups, the alternative solutions, and the consequences of each alternative. You will find tips on how to conduct research in the following section on researching topics.

STEP 4 Generate a list of alternative solutions.

Examine the background of the issue and the viewpoints in order to generate a list of alternative solutions. Brainstorming can be a useful component of this step. Use your research to help guide your thinking.

Examples of possible alternatives for the issue in Step 1 might be as follows:

- Cut the trees and build the playing field.
- Leave the park as it is.
- Find another more suitable location.
- Modify the plan in the existing park.

STEP 5 Analyze the consequences for each alternative.

Decide how you will measure the risks and benefits for the consequences of each alternative solution. The importance of the consequence and the likelihood of its occurrence can be ranked high (3), moderate (2), low (1), or none (0). Duration is considered short term (S) if it is less than 50 years or long term (L) if it is longer than 50 years. Ask how many people will benefit from the alternative and how many will be affected negatively. Make sure to consider health and safety.

For the playing field example, you could analyze the consequences of each alternative solution in a table like the one shown below.

Build the Playing Field in the Park

Consequence	Importance (3, 2, 1, 0)	Likelihood of occurrence (3, 2, 1, 0)	Duration (S, L)
Trees cut	2	3	L
Run-off	3	3	S
Birds move	2 to 1	3	L
Playing field well used	2	2	possibly L
Development and maintenance cost	2 to 1	3	L

STEP 6 Reflect and decide on the best course of action.

Evaluate your decision-making process to ensure that each step is completed as fully as possible. Consider the consequences of the alternative solutions and how people will respond to each one. Then, decide on what you think is the best course of action.

STEP 7 Communicate your findings.

Communicate your findings in an appropriate way. For example, you may prepare a written report, a verbal presentation, or a position for a debate or a public hearing role-play. Defend your position by clearly stating your case and presenting supporting evidence from a variety of sources.

Researching Topics

Research involves finding out something about a topic or subject. That means going to certain resources that will give you accurate information. Information can be found just about anywhere: from your home bookshelves to the public library, from asking experts to looking on the Internet. Here is the process you should follow when you do your research.

Choosing a Topic

In some situations, your teacher may give you the topic to research. Other times, you will select one of your own, such as the issue described in this Skills Reference. If you have trouble coming up with a topic, try brainstorming ideas either by yourself or with a group. Remember, when you brainstorm, there are no right or wrong answers, just ideas. Here are some brainstorming suggestions to get you started:

- List two or three general topics about science that interest you.
- For each topic, spend a few minutes writing down as many words or ideas that relate to that topic as you can. They don't have to be directly connected to science.
- Share your list with others, and ask them to suggest other possibilities.
- Now you have to reduce your idea list to find a topic to research. In other words, go through your ideas until you find two or three that interest you. To help you narrow your idea list, try grouping similar words or ideas, modifying what you've written, or even writing down a new idea. Sometimes, working with other people will help to focus your thoughts.
- When you settle on an idea for your topic, write it down. Try to explain it in a couple of sentences or a short paragraph. Do that for each of your two or three topic ideas.
- Have your teacher approve your topics. Now you're ready to go!

Which Topic Should I Choose?

How does product design help sell a product?

How do gears improve the performance of a bicycle?

The next thing you have to do is settle on one topic. (Remember, you should start your research with two or three topic ideas.) One way to help you decide is to determine how easy it will be to find information on your topic.

- Use some of the resources listed under "Finding Information" to do your preliminary research.
- If you can't easily find at least four good references for a topic, consider dropping it and going on to the next idea.

Hint

Sometimes, topics are too broad in scope or too general to make good research reports (for example, "transportation" instead of just "bicycles"). Try rewriting your topic to narrow its focus.

If all the topics are easy to research, then you'll need some other criteria to help you decide. Think about:

- which topic interests you the most
- which topic is not being researched by many students in your class
- which topic interests you the least

How Hard Will It Be to Find Information?

How camera lenses are manufactured

How mirrors are used in some optical devices

Once you've finally chosen your topic, you might want to work with other students and your teacher to:

- finalize its wording
- make sure it matches the project or assignment you are doing

Finding Information

There are many resources that you can use to look up information. You'll find some of these resources:

- in your school
- in your community (such as your public library)
- on the Internet
- in CD-ROM encyclopedias and databases

Here is a suggested list of resources.

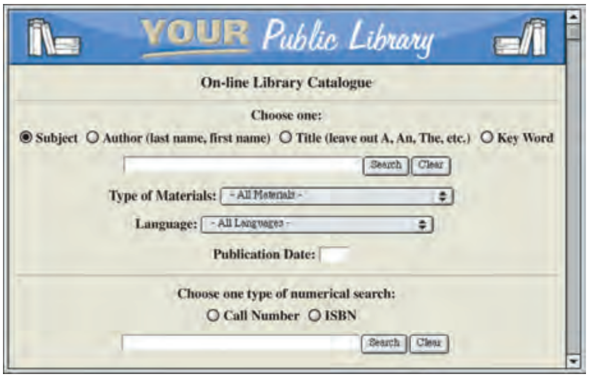
Types of Resources

Resource	✓	Details
Books		
CD-ROMs		
Community professionals or experts		
Encyclopedias		
Films		
Government agencies (local, provincial, and federal)		
Internet sites		
Journals		
Library catalogue		
Newspapers		
Non-profit organizations		
Posters		
DVDs and videos		

Searching Tips

Finding Information at Your Library

Library computer catalogues are a fast way to find books on the subjects you are researching. Most of these electronic catalogues have four ways to search: *subject*, *author*, *title*, and *key words*. If you know the *author* or *title* of a book, just type it in. Otherwise, use the *subject* and *key words* searches to find books on your topic.



- If you're doing a *subject* search, type in the main topic you are researching. For example, if you're searching for information on solar energy, type in "solar energy." If there are no books on that topic, try again using a more general category, like "renewable resources," or just "energy."
- If you're doing a *key words* search, type in any combination of words that have to do with your topic. For the solar energy example, you could type in words such as: "renewable energy sun solar panels." Using several key words will give you a more specific search. Using only one or two key words, like "sun" and "energy," will give you a more general search.

Hints

- The library may also have a way to search for magazine articles. This is called a *periodical search*. It's especially useful for searching for information on events and/or discoveries that have taken place recently. Ask your librarian how to do a periodical search.
- Your library will probably have a reference section where all the encyclopedias are kept. There you may find science and technology, environmental, or even animal encyclopedias, as well as other reference books.

Finding Information on the Internet

On the Internet, you can use searching programs, called *search engines*, to search the Internet on just about any subject. To find a search engine, ask your teacher or click on the search icon found at the top of your Internet browser. Here are some suggestions on how to search the Internet:

- Once you reach a search engine Web page, type in key words or phrases that have to do with your topic. For solar energy, you could type in "solar energy," "solar panels," "renewable resources," or any combination of these and other similar words.

- The search engine will display a list of Web pages it has found that have these words or phrases somewhere in them. Click on any Web page on the list that looks interesting.
- Quite often, you will get a long list of possible Web pages to look at. You may need to make your search more specific. This can be done by adding other key words to your search. For example, if you were looking for solar energy examples in Canada and used the key word "solar energy," you may want to do a second search of these results with the key word "Canada" added.
- Don't forget to record the addresses of any interesting Web pages you find. Work with a friend. One person can record the addresses of Web pages while the other person searches on the computer. Or you can save any Web page as a *bookmark* for easy future access. Check with your teacher or librarian to find out how to save and organize your bookmarks.

BEFORE YOU START!

Check with your teacher to find out what your school's policy is about acceptable use of the Internet. Remember to follow this policy whenever you use the Internet at school. Be aware as you use the Internet that some websites may be strongly biased toward a specific point of view. If you are looking for scientific or technical information, educational or government websites are generally reliable.

Recording Your Information Sources

An important part of researching a topic is keeping track of where you obtain information. As you do your research, you are reading through or viewing a variety of different sources. Some may be in print, such as magazines and books. Others may be electronic, such as websites and CD-ROMs. And others may be visual, such as videos and photos. No matter what sources you use, you should keep track of them.

With this information, you can easily go back and check details. You can also use it to help you respond to any questions about the accuracy or completeness of your information. Your record of sources should include at least the following basic information:

- title or name of the source (e.g., if you read a chapter of a book, you would write down the book's title; for a website, you would include the address)
- author's name, if known
- publisher (e.g., for a website, this would be the name of the person or the organization that has put up the site)
- date of publication
- pages consulted

Your teacher may want you to list your information sources in a specific format. Check what this format will be before you begin your research so that you can collect the details you need to complete your reference list later. You may want to do your own research on formats for such reference lists or bibliographies.

Reading in Science

You use different skills and strategies when reading different materials such as a novel or a textbook. In a novel, you are mainly reading to enjoy the story. In a science textbook, you are reading for information. A science textbook has terms and concepts that you need to understand.

Investigating Science 9 helps you with your non-fiction reading by giving you opportunities to use different reading strategies. You will find these reading strategies in the following literacy activities:

- Before Reading at the beginning of each chapter
- During Reading in each section
- After Reading at the end of each chapter

Using Reading Strategies

You can use the following strategies to help you better understand the information presented in this book.

Before Reading

- Skim the section you are going to read. Look at the headings, subheadings, visuals, and boldfaced words to determine the topic.
- Look at how the information is organized. Ask yourself: Is it a cause-and-effect passage? Is it a contrast-and-compare passage? Think about how the organization can help you access the information.
- Think about what you already know about the topic.
- Predict what you will learn.
- List questions that you have about the topic. This will help you to set a purpose for reading.

During Reading

- Rewrite the section headings and subheadings as questions. Look for the answers to the questions as you read.
- Use your answers to the questions to decide on the main idea in each section or subsection.
- Look carefully at any visuals — photographs, illustrations, charts, or graphs. Read the captions and labels that go with the illustrations and photographs, and the titles of any charts or graphs. Think about the information the visuals give you and how this information helps you understand the ideas presented in the text.
- Notice the terms that are boldfaced (dark and heavy type). These are important words that will help you understand and write about the information in the section. Make sure you understand the terms and how they are used. Check the terms in the Glossary to confirm their meanings.
- Use different strategies to help remember what you read. For example, you can make mental pictures, make connections to what you know, or draw a sketch.

After Reading

- Find the information to answer any review questions. Use the headings and boldfaced terms to locate the information needed. Even if you are sure of the answer, reread to confirm that your answer is correct.
- Write brief notes to synthesize what you have learned, or organize the information in a graphic organizer. You will find information about graphic organizers in Skills Reference 7.
- Personalize the information. Think about opinions you have on what you've read. Consider if the new information you have learned has changed any previous ideas. List questions you still have about the topic.

Note-Taking Chart

A note-taking chart helps you understand how the material you are reading is organized. It also helps you keep track of information as you read.

Your teacher will assign several pages for you to read. Before you begin reading, look at each heading and turn it into a question. Try to use "how," "what," or "why" to begin each question. Write your questions in the left-hand column of your chart. Leave enough space between each question so that you can record information from your reading that answers your question.

For example, you may be assigned several pages about the scientific meaning of work. These pages contain the following headings:

- The Meaning of Work
- Calculating Work
- Energy and Work

You can see an example of a note-taking chart below.

Questions from Headings	Answers from Reading
What is the meaning of the word "work"?	– work is done when a force acts on an object to make the object move – If there's no movement, no work is done – just trying to push something isn't work—it's only work if the object moves
How do you calculate work?	
How are energy and work related?	

Communicating in Science

In science, you use your communication skills to clearly show your knowledge, ideas, and understanding. You can use words and visuals, such as diagrams, charts, and tables, to communicate what you know. Some communication may be short, as in answering questions, or long, as in reports.

Writing Reports

Skills Reference 2 shows you how to plan a science experiment. Skills Reference 3 shows you how to do technological design, and Skills Reference 4 shows you how to use a decision-making process for social and environmental issues. Here you will learn how to write a report so you can communicate the procedure and results of your work.

Here is a list of things you should try to do when writing your science reports.

- Give your report or project a title.
- Tell readers why you did the work.
- State your hypothesis, or describe the design challenge.
- List the materials and equipment you used.
- Describe the steps you took when you did your experiment, designed and made your product, or considered an issue.
- Show your experimental data, the results of testing your product, or the background information on the issue.
- Interpret and analyze the results of your experiment.
- Make conclusions based on the outcome of the experiment, the success of the product you designed, or the research you did on an issue.

Give your report or project a title.

Write a brief title on the top of the first page of your report. Your title can be one or two words that describe a product you designed and made, or it can be a short sentence that summarizes an experiment you performed, or it can state the topic of an issue you explored.

Tell readers why you did the work.

Use a heading such as “Introduction” or “Purpose” for this section. Here, you give your reasons for doing a particular experiment, designing and making a particular product, or considering a specific issue. If you are writing about an experiment, tell readers what your cause-and-effect question is. If you designed a product, explain why this product is needed, what it will do, who might use it, and who might benefit from its use. If you were considering an issue, state what the issue is and why you have prepared this report about it.

State your hypothesis, or describe the design challenge.

If you are writing about an experiment, use a heading such as “Hypothesis.” Under this heading you will state your hypothesis. Your hypothesis is your guess at the solution to a problem or question. It makes a prediction that your experiment will test. Your hypothesis must indicate the relationship between the independent and dependent variables.

If you are writing about a product you designed, use a heading such as “Design Challenge.” Under this heading, you will describe why you decided to design your product the way you did. Explain how and why you chose your design over other possible designs.

List the materials and equipment you used.
This section can come under a heading called "Materials and Equipment." List all the materials and equipment you used for your experiment or design project. Your list can be in point form or set up as a table or chart. Remember to include the exact amounts of materials used, when possible (for example, the number of nails used in building a model or the volumes and masses of substances tested in an experiment). Include the exact measurements and proper units for all materials used.

Also include diagrams to show how you set up your equipment or how you prepared your materials. Remember to label the important features on your diagrams. (See the next few pages on diagrams for drawing tips.)

Describe the steps you took when you did your experiment, designed and made your product, or researched the issue.
Under a heading called "Procedure" or "Method," describe, in detail, the steps you followed when doing your experiment, designing and making your product, or considering an issue. If you made a product, describe how you tested it. If you had to alter your design, describe in detail how you did this.

Show your experimental data, the results of testing your product, or the background information on the issue.
Give this section a heading such as "Data," "Observations," or "Background Information." In this section, you should show the data or information you collected while performing the experiment, testing your product, or researching an issue. In reporting about an issue, use only a summary of the essential information needed for a reader to understand the issue and different viewpoints about it.

Use tables, diagrams, and any other visual aids that show the results of your tests. If you performed your experiment a few times, give results for each trial. If you tested different designs of your product, give results for each design.

Interpret and analyze the results of your experiment.
Interpret and analyze the data you collected in your experiment. Calculations, graphs, diagrams, charts, or other visual aids may be needed. (See Skills Reference 9 for graphing tips.) Explain any calculations or graphs that you used to help explain your results.

Make conclusions based on the outcome of the experiment, the success of the product you designed, or the research you did on an issue.
This last section of your report can be called "Conclusions." In one or two paragraphs, explain what your tests and experiments showed or what decision you made as a result of your research.

If you did an experiment, explain if your results were predicted by the hypothesis. Describe how you might adjust the hypothesis because of what you learned from doing the experiment and how you might test this new hypothesis.

If you made a product, explain if your design did what it was supposed to do or worked the way it was supposed to work.

If you changed the design of your product, explain why one design is better than another.

Describe the practical applications your product or experiment might have for the world outside the classroom.

If you considered an issue, explain why you made your decision. Briefly summarize your supporting evidence. If necessary, explain how you have responded to different viewpoints on the issue.

Diagrams

In science, a carefully done diagram can help you express your ideas, record important information, and experiment with designs. Diagrams are an important tool in communicating what you know and your ideas.

Four types of diagrams you can use are a simple sketch, an isometric diagram, an orthographic (perspective) diagram, and a computer-assisted diagram. Examples of these types of diagrams are shown on the next page.

The photo on this page shows the set-up of an experiment. Practise drawing it using one or several of the diagram types presented on the next page.

Tools of the Trade

You will need the following equipment for each type of diagram.

Hand-drawing tools

- a sharp pencil or mechanical pencil
- a pencil sharpener or extra leads
- an eraser
- a ruler

For simple and isometric diagrams

- blank white paper

For computer-assisted diagrams

- access to computer and software

For orthographic drawings

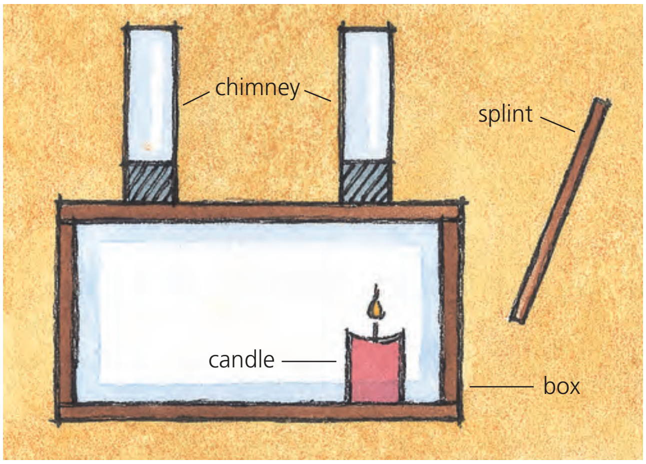
- blank orthographic graph paper

Remember!

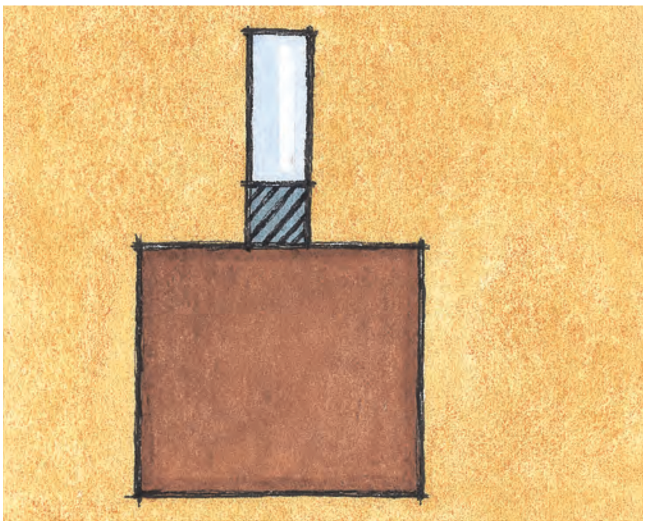
- Give your diagram a title at the top of the page.
- Use the whole page for your diagram.
- Include only those details that are necessary, keep them simple, and identify them by name.
- If you need labels, use lines, not arrows. Place your labels in line with the feature being labelled, and use a ruler to keep your lines straight.
- Don't use colour or shading unless your teacher asks you to.
- Include notes and ideas if the sketch is a design for a structure or an invention.

Hint
If you're going to use your diagram to help you design a structure, include a front, side, and top view.

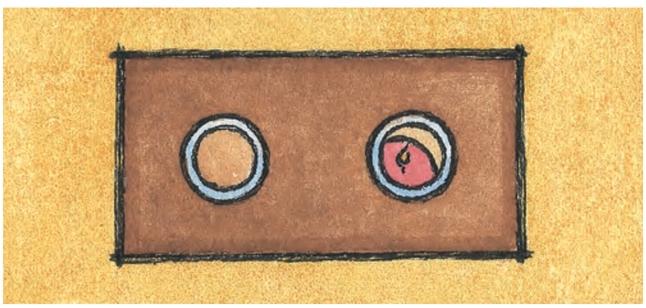
A Simple Sketch (Front View)



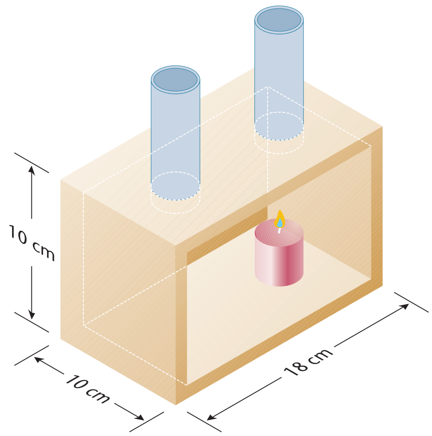
A Simple Sketch (Side View)



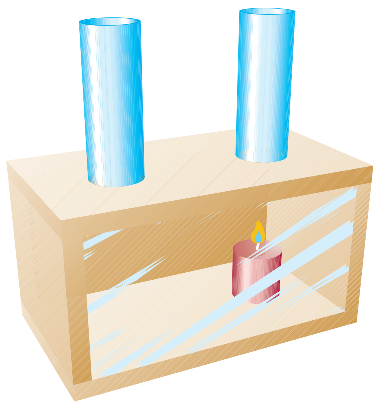
A Simple Sketch (Top View)



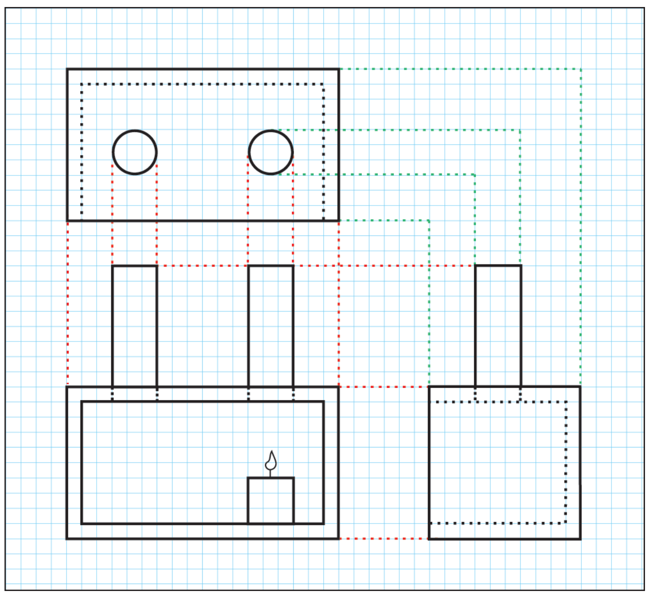
An Isometric Diagram



A Computer-Assisted Diagram

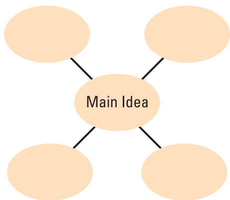
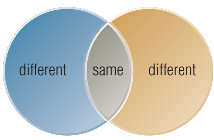
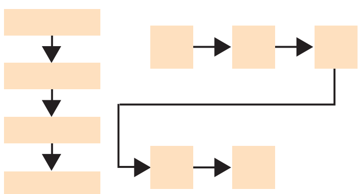
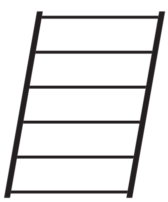
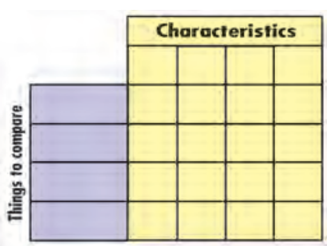


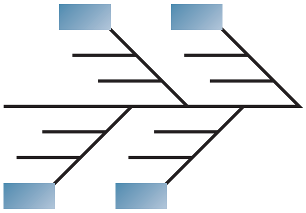
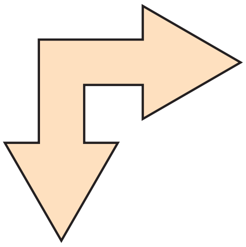
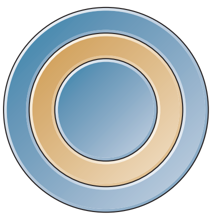
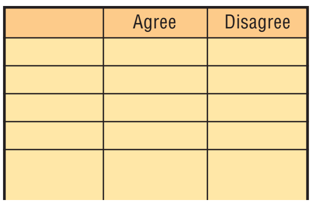
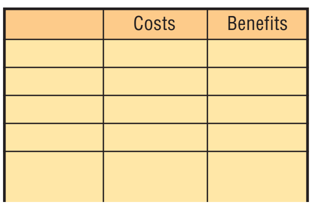
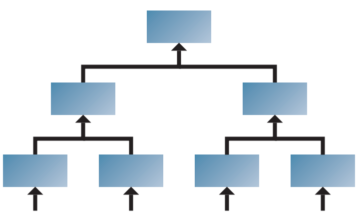
An Orthographic (Perspective) Drawing



Graphic Organizers

Graphic organizers can be used to organize information that you read, and to display ideas visually.

Type of Graphic Organizer	Purpose	Method
Concept map or web diagram 	Used to clarify relationships and linkages between concepts, events, or ideas	Brainstorm ideas and link together from "big to small" with arrows or lines linking words. Cluster information around a central concept or idea.
Venn diagram 	Used to visualize similarities and differences between two or more ideas, topics, or concepts	Brainstorm similarities, and list these in the overlapping section of the two circles. Then, brainstorm differences, and list these in the non-overlapping sections.
Flowchart or sequence chart 	Used to map out your thinking about an issue or to organize ideas for an essay or report	Brainstorm aspects of the whole event or concept. Select important aspects, and put them into sequential order.
Ranking ladder 	Used to rank ideas in order of importance	Brainstorm ideas, and rank them in order from most important (bottom rung) to least important (top rung).
Comparison matrix 	Used to compare the characteristics or properties of a number of things	Brainstorm what you want to compare. Write the characteristics of the things that you will compare and how the things you compare are similar or different.

Type of Graphic Organizer	Purpose	Method
Fishbone diagram 	Used to analyze cause-and-effect relationships	List the effect at the head of the "fish." Brainstorm possible causes, and list them in each "bone." Rank the causes and circle the most probable ones, justifying your choice.
Right-angle diagram 	Used to explore the consequences of an idea and the impact of its application	Briefly describe the idea you are exploring on the horizontal arrow. Brainstorm consequences of the idea, and list these to the right of the horizontal arrow. Expand on one consequence, and list details about it along the vertical arrow. Describe social impacts of that consequence below the vertical arrow.
Target diagram 	Used to weigh the importance of facts and ideas	Brainstorm facts and ideas. Rank their importance and place the most important facts or ideas centrally and the least important toward the outer ring.
Agree/disagree chart 	Used to organize data to support a position for or against an idea or decision	List a series of statements relating to a topic or issue. Survey agreement and disagreement before discussion. Survey again after discussion and research.
Cost/benefit chart 	Used to summarize the negative (costs) and positive (benefits) aspects of a topic or issue	List ideas or information relating to the topic or issue. Sort the ideas or information in a chart that includes the headings "Costs" and "Benefits."
Tree diagram 	Used to identify and sequence the concepts by placing the main concept at the top of the diagram and all the parts below it	Place the main concept at the top of the page. Then, consider the question "What concepts need to be understood before the concept above can be grasped?" The same question is then asked for each of the parts, and a hierarchy of connected concepts is created.

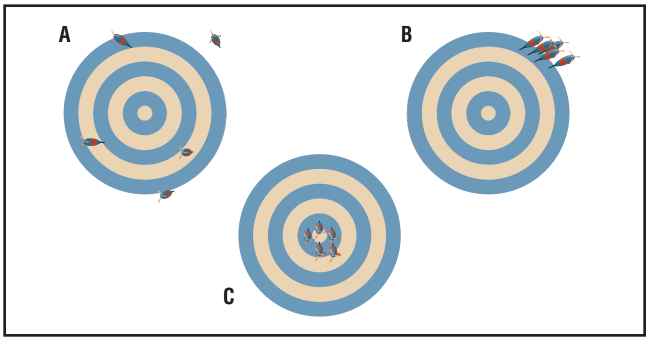
Measurement

Observations from an experiment may be qualitative (descriptive) or quantitative (physical measurements). Quantitative observations help us to describe such things as how far away something is, how massive it is, and how much space it takes up. Quantitative observations require the use of accurate measurements.

Measurement and Accuracy

Whenever you take a measurement, you are making an estimate. There is always an amount of uncertainty in measured values. Counted and defined values are exact numbers and so have no uncertainty. For example, 32 students in a classroom is a counted number, and a length of 1 m is defined as exactly equal to 100 cm. There is no estimation in these values and so no uncertainty.

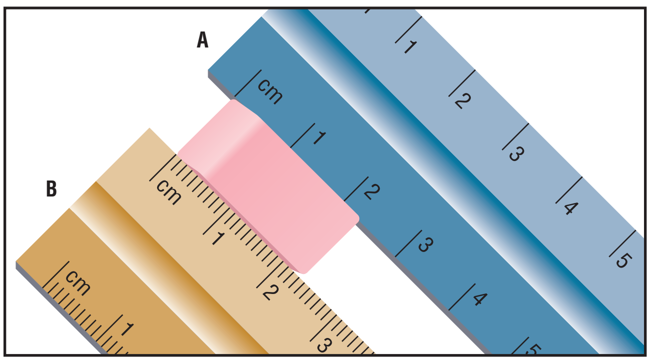
Accuracy is the difference between a measurement and its true value. No matter how carefully you work, there will be a difference between a quantity you measure and its true value. The accuracy of any measurement is affected by the precision of the measurement. Precision refers to the degree of agreement among repeated measurements of the sample (the reproducibility). Precision is determined by your actions; how carefully you take measurements and control the variables in your experiment. The differences between precision and accuracy are illustrated using the example of a darts game.



In this illustration, the centre of the dartboard is the true value of the measurement. Player A was neither precise nor accurate; the positions of the shots all differed and none hit the centre. Player B was precise but not accurate; all the darts hit the same area of the target, but they all were off the centre. Player C was both precise and accurate; all the darts are close to one another and in the centre of the target.

Significant Digits

Significant digits are the specific number of digits used to communicate the degree of uncertainty in a measurement. The last digit indicates the uncertain (or estimated) digit. The measurement of 2.5 cm for the eraser taken with ruler A below has two significant digits, but the measurement of 2.35 cm taken using ruler B has three significant digits. When a measurement is on a division on a scale, indicate it by including a zero. For example, a length on the 3-cm mark would be recorded as 3.0 cm (two significant digits) on ruler A, and as 3.00 cm (three significant digits) on ruler B.



A mark on ruler A would be recorded to two significant digits, and to three significant digits on ruler B.

Measuring in SI

Most countries and scientific communities have agreed on the use of one system of measurement, making worldwide communication much more efficient. This system is called “le Système international d’unités” or SI for short. SI is based on the metric system. Base units are used, and prefixes are added to change the base units by multiples of ten. Conversion from one unit to another is relatively easy if you know the base units and the meaning of the prefixes. The table below shows the prefixes, their symbols, and their meanings. A kilometre, for example, is equal to 1000 m, and 1 millimetre is 0.001 m or 1 m = 1000 mm.

Common Metric Prefixes

Prefix	Symbol	Meaning	Exponential Form
giga	G	billion	10^9
mega	M	million	10^6
kilo	k	thousand	10^3
hecto	h	hundred	10^2
deca	da	ten	10
deci	d	one tenth	10^{-1}
centi	c	one hundredth	10^{-2}
milli	m	one thousandth	10^{-3}
micro	μ	one millionth	10^{-6}

Scientific Notation

Scientific notation is often used to express either very large or very small numbers. It is based on the use of exponents. A number between 1 and 10 is followed by 10 raised to a power.

Example 8.1: Write 0.000 15 mm in scientific notation.

In scientific notation, there must be one digit before the decimal place. So, you need to move the decimal four places to the right and then multiply by 10^{-4}.

0.000 15 mm is written as 1.5×10^{-4} mm

Example 8.2: Write 2.998×10^8 m/s in common notation.

The power term 10^8 tells you to move the decimal over 8 places to the right.

2.998×10^8 m/s is written as 299 800 000 m/s

SI Base Units

Measurement	Base Unit	Symbol
mass	kilogram	kg
length	metre	m
temperature	Kelvin	K
time	second	s
electric current	ampere	A
amount of substance	mole	mol
intensity of light	candela	cd

Converting SI Units

It is important to know how to convert from one SI unit to another. The following steps will help you convert between units.

1. Begin by writing the measurement that you want to convert.
2. Multiply by a factor that shows the relationship between the two units you are converting. Write this relationship as a fraction, putting the units you are converting to in the numerator. This will allow you to cancel the given units you started with.

3. The conversion may sometimes require two or more steps. (see Example 8.4). This method of solving problems is referred to as unit analysis.

Example 8.3: Express 56 cm in metres.

Multiple the number by its conversion factor, and cancel out any repeated units:

$$56 \cancel{\text{cm}} \times \frac{1 \text{ m}}{100 \cancel{\text{cm}}}$$

$$= \frac{56 \text{ m}}{100}$$

$$= 0.56 \text{ m}$$

Example 8.4: Express 3200 cm in kilometres.

Multiple the number by its conversion factor, and cancel out any repeated units:

$$3200 \cancel{\text{cm}} \times \frac{1 \cancel{\text{m}}}{100 \cancel{\text{cm}}} \times \frac{1 \text{ km}}{1000 \cancel{\text{m}}}$$

$$= \frac{3200 \text{ km}}{100 \times 1000}$$

$$= 0.\ 3200 \text{ km}$$

Length

Length indicates the distance between two points. The metre is the base unit for measuring length. Long distances are measured in kilometres (km), and small distances are commonly measured in centimetres (cm) or millimetres (mm). The instrument that you use will determine the number of decimal places in your measurement. The last digit of any measurement is always uncertain.

When you use a measuring tool such as a ruler, look directly in line with the measurement point, not from an angle. This coin measures 28.0 mm or 2.80 cm.

Hint

When you use a ruler, tape measure, or metre-stick, always start from the 0 measurement point, not the edge of the measuring tool.

Instant Practice

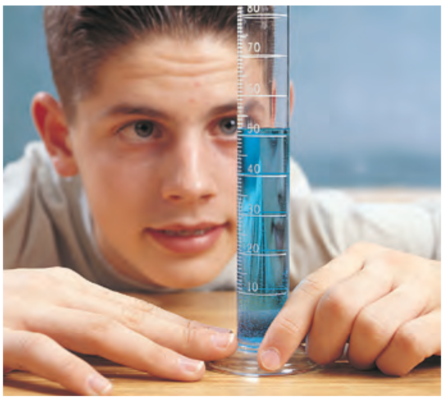
For each of the following, choose the unit of measurement that you think would be used. Explain why you chose that unit of measurement in each case.

1. the height of a table
2. the depth of a lake
3. the width of a dime
4. the length of a skating rink
5. the distance from Ottawa, Ontario, to Victoria, British Columbia

Volume

Volume indicates the amount of space that something takes up (occupies). Common units used to measure volume include litres (L) for liquids and cubic centimetres (cm^3) for solids. Remember that 1 mL = 1 cm^3.

At home, you often use a measuring cup to determine the volume of something. At school, you usually use a graduated cylinder. Here, “graduated” means a container that has been marked with regular intervals for measuring. For example, a measuring cup, a beaker, and a thermometer are all graduated, but the accuracy of the measurement is different with each measuring instrument or tool.



When you add a liquid to a graduated cylinder, the top of the liquid is curved near the sides of the cylinder. This curve is called a *meniscus*. To measure the liquid’s volume properly, you need to observe the liquid’s surface from eye level so you can see the flat, bottom portion of the curve. Ignore the sides.

Instant Practice

1. Each of the following objects takes up space. Estimate the volume of each, using appropriate units.
   (a) soccer ball
   (b) tissue box
   (c) Olympic swimming pool
2. Explain how you could accurately measure 53 mL of water in the school laboratory.

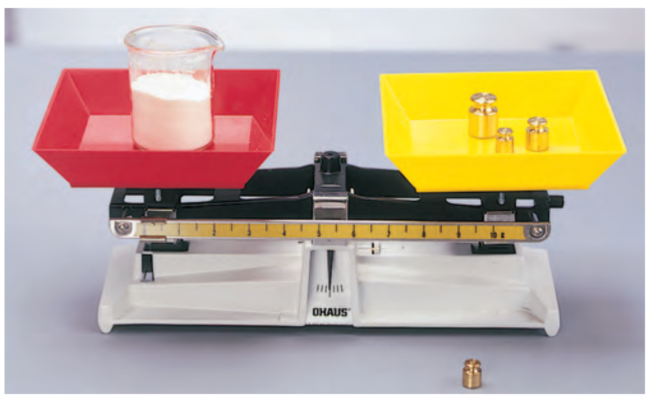
Mass and Weight

The terms mass and weight do not mean the same thing, even though they are often used that way. The mass of something tells you the amount of matter it contains. The weight of an object is a measure of the force of gravity acting on it.

Common units to measure mass include grams (g) and kilograms (kg). The mass of objects is often measured in grams using different types of balances. You may have a triple beam balance, an equal arm balance, or an electronic scale in your school.

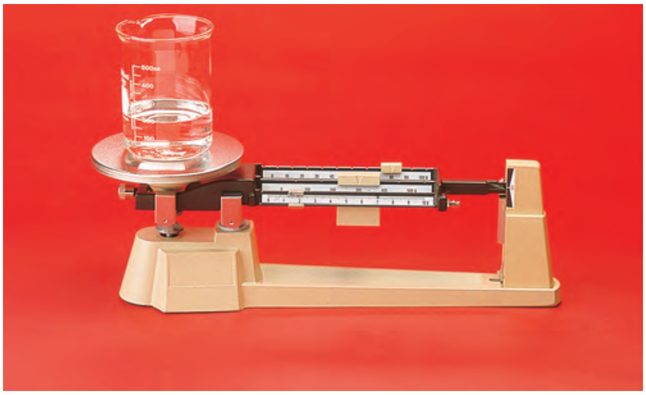
The equal arm balance and triple beam balance basically work in the same way. You compare the mass of the object you are measuring with standard or known masses (or their mass equivalent values on the triple beam).

An equal arm balance has two pans. You place the object whose mass you want to know on one pan. On the other pan, you place standard (known) masses until the two pans are balanced (level). Then, you just add up the values of the standard masses. The total is the mass of the object you are measuring.



Equal arm balance

A triple beam balance has a single pan. You place the object you are measuring on the pan. You adjust the masses on the beams until the beam assembly is level. Then, you add up the mass equivalent values of the beam masses from the scales on the beam.



Triple beam balance

Electronic balances allow you to tare (zero) the balance with an object on it. For example, this allows you to ignore the mass of a beaker and measure the mass directly. You do not have to subtract the mass of the beaker.

Electronic balance

You can use a spring scale to measure weight, which is the force of gravity acting on an object. A spring scale is sometimes called a force meter and measures force in newtons.

A spring scale has three main parts: a hook, a spring, and a measuring scale. The hook at the end is used to attach the object to the scale. The spring pulls on the object. As the spring pulls, the pointer moves along the measuring scale.

Spring scale

To measure the weight of an object, first hang the spring scale from a clamp on a retort stand. Then, hang the object from the hook of the spring scale. Once the pointer stops moving, record the measurement.

Instant Practice

1. The object on the triple beam balance is a water-filled beaker, so the balance is measuring the mass of the water plus the mass of the beaker. What if you wanted to measure just the mass of the water in the beaker? Describe, step-by-step, how you would do it.
2. How would you measure the mass of an apple? How would this be similar to and different from measuring the mass of a pile of salt?

Temperature

The Celsius temperature scale is commonly used in the metric system, even though the Kelvin degree is the base unit. You will use the Kelvin scale as you learn more about matter in higher grades. Water boils at 100°C and freezes at 0°C.

Estimating

It is important to be able to estimate or guess the length, mass, or volume of various objects before you measure. This process will allow you to decide whether your measurements are accurate or if there is instrument error. It will also help you to decide which tool to use. Sometimes, you can estimate by comparing one object with another object that has known measurements. For example, if you are asked to estimate the volume of your drink, you could estimate by comparing it with a large jar of mayonnaise in your fridge, which has its volume marked on the label.

For a large object or distance, you might divide it up into portions in your mind and guess the length, volume, or mass of one portion. You then multiply that guess by the number of imaginary portions to estimate the measurement of the whole.

To estimate the volume of your drink, you can compare it with the known volume of a jar of mayonnaise.

Sometimes, it is useful to estimate the measurement of an object before you actually measure it. You might do this to help you decide which units of measurement and which measuring tool to use. In other cases, you might not be able to measure an object at all. In this case, an estimate of its length, volume, or mass might be the best you can do.

Try to estimate the measurements of the items listed below. Include the measurement units that you think should go with your estimates. Then, measure them to see how close your estimates were to the real values. If you don't have some of these items in your classroom, check at home.

Estimating Length

Object	Length	
	estimate (cm)	actual value (cm)
pencil		
height of your teacher's desk		
length of your classroom		

Estimating Mass

Object	Mass	
	estimate (g)	actual value (g)
this textbook		
banana from someone's lunch		
piece of chalk		

Estimating Volume

Object	Volume	
	estimate (mL)	actual value (mL)
amount of water poured into an empty jar		
marker cap		
drink thermos		

Graphing

Science and technology often involve collecting a lot of numerical data. It is important to record these data or observations in an organized, meaningful manner. Data tables are helpful tools for organizing information.

Sometimes, however, it's difficult to see if there are any patterns in the numbers. That's when it's useful to reorganize the data into graphs. Graphs help to interpret data collected during an experiment.

A graph is similar to a picture or diagram that shows more easily how numbers are related to one another. You have probably drawn a lot of graphs over the years in your studies of mathematics, geography, and, of course, science and technology.

Bar Graphs

Bar graphs are useful when you want to analyze the relationship between quantitative data in different categories. For example, the table shows the average monthly precipitation in a Canadian city. In this example, the independent variable is a category, a month, and the depenedent variable is the average precipitation. The graph is created from the data in the table.

On a bar graph, the independent variable (e.g., the month) is plotted on the x-axis and the dependent variable (e.g., the average precipitation) is plotted on the y-axis. The x-axis is the horizontal axis, and the y-axis is the vertical axis. The maximum number on the scale of the y-axis is determined by the maximum value in the data set. If all the values in the data set are positive, the minimum number on the scale is usually zero. If the data set contains negative numbers, then the minimum value in the data set will be the minimum number on the y-axis.

Each category in the data set is drawn as a bar of equal width on the x-axis. The height of each bar is determined by the value of the dependent variable, and it is drawn according to the scale of the y-axis. The graph is given a title, placed at the top of the graph, which describes the information presented. Bar graphs may be drawn by hand using paper and pencil, or using technology such as a graphing calculator or spreadsheet software. As you can see, the changes in the dependent variable are a lot easier to see on the graph than in the table.

Average Precipitation per Month

Month	Average Precipitation (mm)
Jan	31.1
Feb	17.4
Mar	15.7
Apr	21.2
May	28.6
June	49.9
July	56.2
Aug	50.6
Sept	37.0
Oct	30.9
Nov	28.2
Dec	26.8

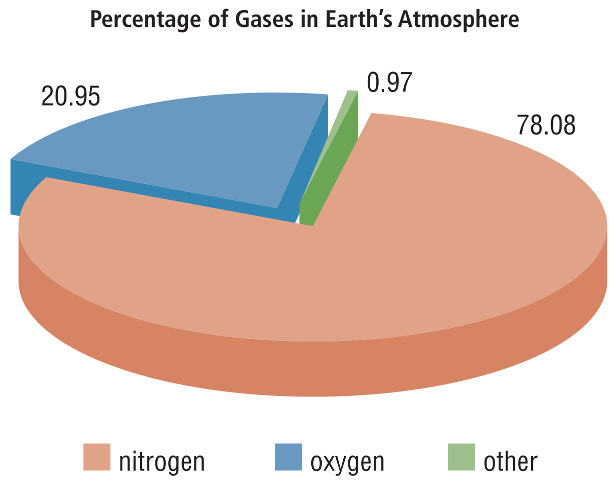
Data Source: Environment Canada

Instant Practice

1. What type of information is a bar graph useful for displaying?
2. Which axis is used to display the independent variable?
3. Refer to the bar graph of Average Precipitation per Month
   (a) Which month received the greatest amount of precipitation?
   (b) In how many months did precipitation greater than 30 mm occur?
   (c) Which season is the wettest?
   (d) What is the least amount of precipitation that occured in any month of the year?

Circle Graphs

A circle graph is useful when you want to display data that are parts of a whole. For example, in this circle graph, the whole circle represents Earth's atmosphere and the parts show the percentage of each specific gas. The graph is given a title that describes the information it contains, and each part of the circle is clearly labelled. Circle graphs may be drawn by hand using paper and pencil, or using technology such as a graphing calculator or spreadsheet software.



Instant Practice

1. What type of information is a circle graph useful for displaying?
2. Refer to the circle graph of the Percentage of Gases in Earth's Atmosphere.
   (a) Which gas is present in the greatest amount in the atmosphere?
   (b) What percentage of the atmosphere is composed of oxygen?

Line Graphs

Line graphs are good for exploring data collected for many types of experiments. Using line graphs is a good way to analyze the data of an experiment that are continually changing.

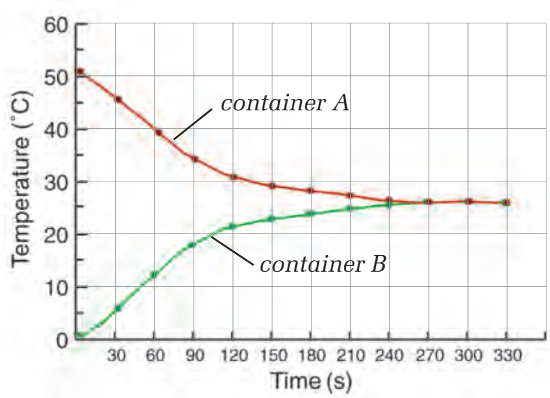
The table shows data collected by a group of students investigating temperature changes. They poured hot water into a large container (container A) and cold water into a smaller container (container B). After recording the starting temperatures in each container, they placed Container B inside Container A and took measurements every 30 s until there were no more temperature changes.

Temperature of Water in Container A and Container B

Time (s)	Temperature (°C) of Water in Container A	Temperature (°C) of Water in Container B
0	51	0
30	45	7
60	38	14
90	33	20
120	30	22
150	29	23
180	28	24
210	27	25
240	26	26
270	26	26
300	26	26

Here are the data the students investigating temperature changes collected shown as a line graph. On the graph, they put the independent variable, time, on the *x*-axis, and the dependent variable, temperature, on the *y*-axis.

Temperature of Water in Container A and Container B



On a line graph, the independent variable is plotted on the *x*-axis and the dependent variable is plotted on the *y*-axis. Each axis must be clearly marked with a scale, which must take into account the entire range of measurements to be plotted and use up at least half the size of the graph paper used. The maximum and minimum numbers of the data determine the maximum and minimum numbers on the scales of the axes.

Each piece of data in the table is then plotted by moving over to the correct position on the *x*-axis and up to the correct position on the *y*-axis. A point is placed at the intersection of these two positions. If two or more sets of data are plotted on one graph, different colours or shapes are used to plot the different data sets and a legend is provided to explain the colours or shapes. When the line graph is completed, it is given a title that describes the information presented. Line graphs may be drawn by hand using paper and pencil, or using technology such as a graphing calculator or spreadsheet software.

Always look for a pattern on the graph after the individual points are plotted and before you connect the points. If you observe a pattern, draw a "line of best fit" with the points evenly located either on or around the line. This process is called interpolation.

If there is more than one line on the graph, you will need a legend to explain what each line represents.

Extrapolation is used in graphing to make predictions. When you extrapolate, you extend the line you obtained from your experimental data to show the relationship between the data for values that were not experimentally determined. This assumes that the trend that was observed will continue further, which is not always the case.

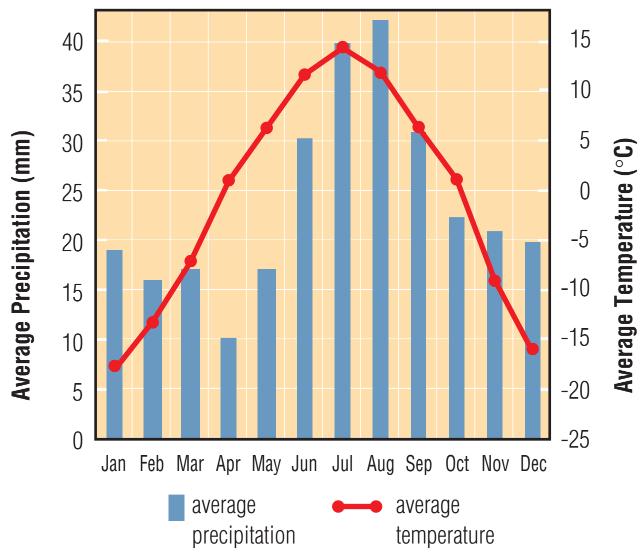
Instant Practice

1. The axes are the two number lines that run horizontally and vertically. Which is the *x*-axis, and which is the *y*-axis? Which axis is used for the independent variable? Which is used for the dependent variable?
2. How was the scale for each axis chosen?
3. How was each point on the graph plotted (placed on the graph)?

Combining Different Types of Graphs

In some cases, two different types of data may be combined on one graph. There are two vertical axes, as shown in the graph. The vertical axis on the left presents the scale for the precipitation data, and the vertical axis on the right presents the scale for the temperature data.

Average Precipitation and Temperature per Month



Source: Environment Canada

Instant Practice

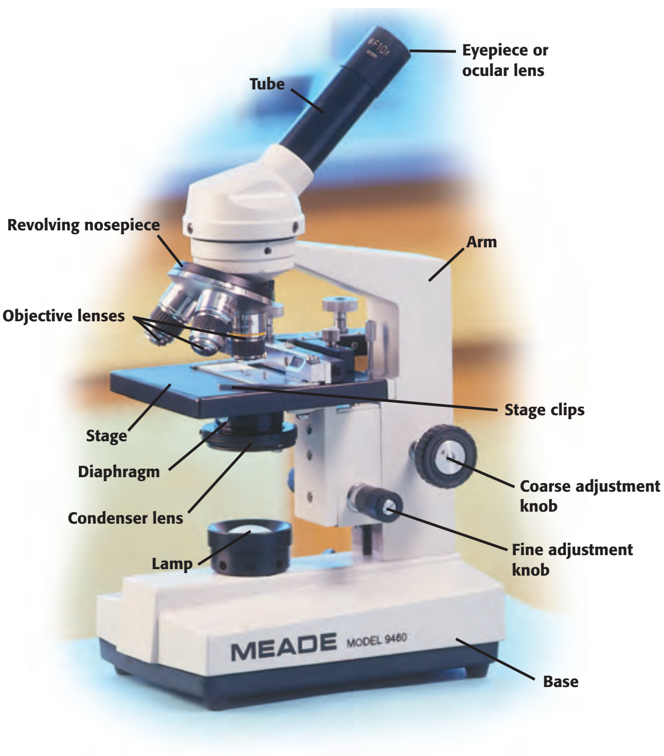
1. Why is it useful to combine a precipitation graph and a temperature graph together?
2. In the combined graph of Average Precipitation and Temperature per Month, how do you determine whether the red line refers to precipitation or temperature?

Using a Microscope

A microscope allows us to see an image of an object that is too small to see with the unaided human eye. A light microscope functions by focussing a beam of light through the object into the lens of the microscope. A compound light microscope is any light microscope that contains more than one lens. The compound light microscope you will use in the science classroom contains an eyepiece lens and a number of objective lenses. Each objective lens is a combination of two lenses made of different kinds of glass.

The Parts of the Microscope

It is important to know the location and function of the parts of the microscope in order to use it correctly. These are shown below.



A compound light microscope

Using the Microscope

1. Carry the microscope with two hands, grasping the arm of the microscope with one hand and holding the base of the microscope with the other. Place the microscope on the table or bench so that the arm is facing you.
2. Plug in the microscope, and turn on the light.
3. Rotate the nosepiece until the objective lens with the lowest power is in place.
4. Place a microscope slide on the stage, and secure with the stage clips.
5. Watch the stage from one side of the microscope, and slowly raise the stage with the coarse adjustment until it is as close to the nosepiece as possible without touching it. Ensure the lens does not touch the slide.
6. Look through the eyepiece. Slowly turn the coarse adjustment so that you move the slide away from the lens. Stop when the image comes into view.
7. Use the fine adjustment to sharpen the focus of the image.
8. If you need to view the object under higher magnification, watch from the side of the microscope and rotate the nosepiece until the next higher power objective lens is in place. Ensure the lens does not touch the slide. Use only the fine adjustment knob to focus the image.

Magnification and Field of View

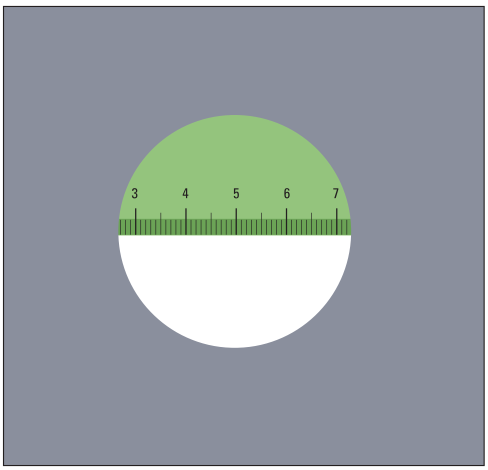
Each lens on the compound microscope will magnify a sample to a different degree. Magnification is calculated by multiplying the power of the ocular lens (usually 10× power) by the magnification of the objective lens you are using.

magnification = (power of ocular lens)(power of objective lens)

For example, if you are viewing a slide using a 4× power objective lens, the magnification of the image would be $(10\times)(4\times) = 40\times$.

The field of view is the entire area that you see when you look through the microscope. The diameter of the field of view varies with the particular objective lens you are using. The diameters of the field of view for low-power (4×) and medium-power (10×) objective lenses can be determined by the following steps:

1. Rotate the objective lens into position.
2. Place a small, transparent, metric ruler on the stage so that it covers about half the stage. The ruler must be small enough to fit on the stage.
3. Using the coarse adjustment knob, bring the ruler into focus. Adjust the placement of the ruler so that the scale crosses the centre of the circle (the diameter), as shown below.
4. Use the fine adjustment knob to get a clear, sharp image. If necessary, adjust the ruler so that one of the markings on the left side is exactly at the edge of the diameter.



Step 4

5. Determine the diameter of the field of view in millimetres, using the scale on the ruler. Convert the millimetre reading to micrometres. This is the field of view for the magnification used.

You cannot measure the diameter of the field of view of a high-power (40×) objective lens using this method, because the field of view is less than 1 mm. However, you can estimate the diameter of the field of view of a high-power objective lens by using ratios. As you increase magnification by a certain amount, you decrease the diameter of the field of view by the inverse of that amount.

Therefore, you can determine the diameter of the field of view of a high-power (HP) objective lens by using the following ratio:

$$\frac{\text{HP field diameter}}{\text{LP field diameter}} = \frac{\text{LP magnification}}{\text{HP magnification}}$$

Example 10.1

A student measured the field diameter of a microscope using the 4× and 10× objective lenses.

Objective Lens	Magnification of Objective Lens	Field Diameter (mm)	Field Diameter (μm)
low power	4×	4.5	4500 or 4.5×10^3
medium power	10×	1.1	1100 or 1.1×10^3

Calculate the field diameter of a high-power (40×) objective lens.

$$\frac{\text{HP field diameter}}{\text{LP field diameter}} = \frac{\text{LP magnification}}{\text{HP magnification}}$$

$$\begin{aligned}\text{HP field diameter} &= \text{LP field diameter} \times \frac{\text{LP magnification}}{\text{HP magnification}}\\ &= 4500\ \mu\text{m} \times \frac{(4\cancel{\times})}{(40\cancel{\times})}\\ &= 450\ \mu\text{m}\\ &= 4.5 \times 10^2\ \mu\text{m}\end{aligned}$$

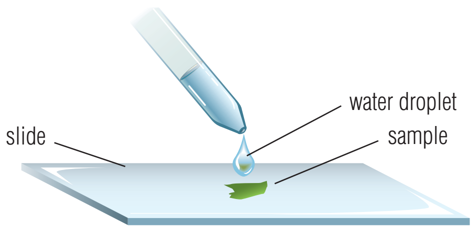
The field diameter of the high-power (40×) objective lens is 4.5×10^2 μm.

Note that when the magnification increases by a factor of 10, such as from 4× to 40×, the field diameter decreases by the same factor (10×), from 4500 μm to 450 μm.

Once you have estimated the diameter of the field of view of an objective lens, you can estimate the size of any structure you are viewing with that lens. Compare the size of the structure with the diameter of the field of view.

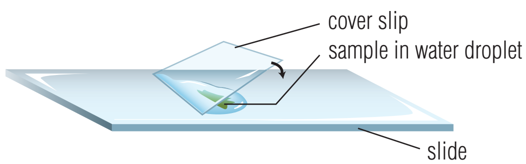
Preparing a Wet Mount

1. Obtain a clean microscope slide and cover slip. In a wet mount, the cover slip serves three functions: it flattens the sample, it prevents the sample from drying out, and it protects the objective lens from contamination.
2. Place your sample in the centre of the slide. The specimen must be thin enough for light to pass through.
3. With an eyedropper, place a drop of water on the sample, as shown.



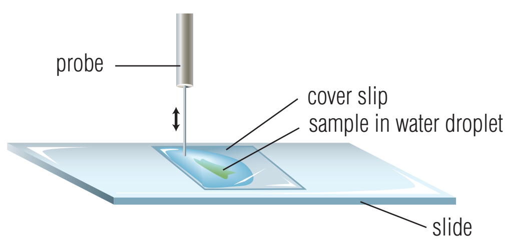
Step 3

4. Place the cover slip at an angle at one end of the drop of water. See below. Carefully lower the cover slip to cover the sample, being careful not to trap any air. It may be helpful to use a probe or toothpick to lower the cover slip.



Step 4

5. If you do get air bubbles, gently tap the slide with a probe to release them, see below.



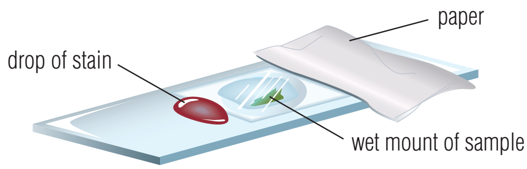
Step 5

Staining Samples

The parts of a cell are composed of various substances, and the different cell components react differently to many chemicals. Stains are chemicals that react in specific ways to different cell components. Stains therefore make it easier to distinguish the components of a cell. Some stains will dye only certain parts of the cell. Others change colour depending on the substances that comprise the different cell components.

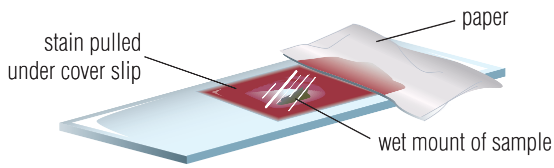
There are many ways to stain cells, but one of the most common is the flow technique. This technique may be used to stain cells with, for example, iodine or methylene blue. The flow technique consists of the following steps:

1. Prepare a wet mount slide, as described at left.
2. Place a drop of stain at the edge of one side of the cover slip.
3. Obtain a small piece of paper towel or tissue paper. Place the paper against the edge of the cover slip on the side opposite to the stain, as shown below.



Step 3

4. Allow the paper to wick the fluid from under the cover slip and draw the stain into the sample, as shown below.



Step 4

5. Remove the paper when the stain has travelled to the other side of the cover slip.
6. If the stain is too dark, it may be diluted by repeating steps 2 to 5 with a drop of water.

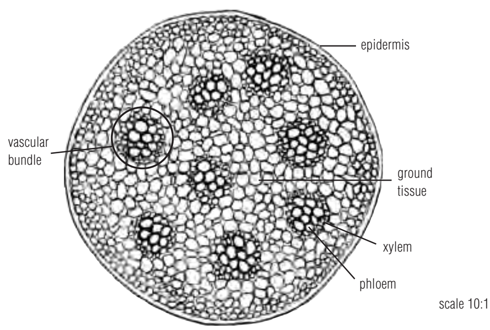
Drawing Scientific Diagrams

To record what you observe under a microscope, you will often draw a scientific diagram. Scientific diagrams can also be used to record observations not made with a microscope. For example, they may also be used to show how equipment is set up for an experiment or to record objects observed with the unaided eye. A scientific diagram is a record of exactly what was observed, with all features accurately drawn and identified.

Guidelines for Drawing Scientific Diagrams

1. Give a title for your diagram at the top of the page. The title should include information about the object shown.
2. Use pencil. Do not colour diagrams. Shade areas if necessary.
3. Draw only one diagram on a page unless otherwise instructed by your teacher.
4. Label the parts or structures of the object on the diagram. Use a ruler to draw lines to connect the label to the part or structure.
5. Record the scale of the drawing at the side of the diagram.

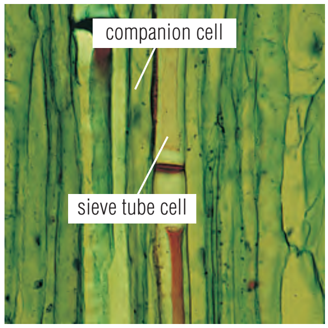
Cross-Section of Plant Stem



This example of a scientific diagram shows the features of a cross-sectional view of a plant stem.

When samples have been dissected (cut apart), it is important to note how they were prepared in the title of the diagram. A sample can be prepared as a cross-section (across the width) or as a longitudinal section (lengthwise), as below.

Longitudinal Section of Plant Stem



This longitudinal view of a plant stem shows different features of the plant stem from those shown in a cross-section.

Diagrams may be drawn larger, smaller, or the same size as the actual object. The scale of a diagram is the difference between the size of the diagram and the size of the actual object. Scale is often expressed as a ratio, such as in the examples in the table.

Actual Size, Diagram Size, and Scale

Actual Size	Diagram Size	Scale
1.1 mm	11 cm (110 mm)	100:1 (or × 100)
2.6 m	2.6 cm	1:100 (or × 0.01)

When using a microscope, the actual size of the object is usually estimated by comparing it to the diameter of the field of view.

To calculate actual size and scale for a scientific diagram, you must first measure the field diameter (if you are using a microscope) and the size of the finished diagram. Actual size and scale can then be calculated using the following relationships:

$$\text{actual size of object} = \frac{\text{field diameter}}{\text{number of objects estimated to fit across field}}$$

$$\text{scale} = \frac{\text{diagram size of objects (units)}}{\text{actual size (units)}}$$

Chemistry Backgrounder

The tables provided here are designed to help you in your study of chemistry.

Common Elements and Compounds

Common Name	Scientific Name	Chemical Formula	Main Uses
Acetic acid	ethanoic acid	$CH_3COOH(aq)$	vinegar
Ammonia water	ammonia	$NH_3(aq)$	cleansers, deodorizers, etching of aluminum
ASA	acetylsalicylic acid	$CH_3COOC_6H_4COOH(s)$	pain reliever
Baking soda	sodium hydrogen carbonate	$NaHCO_3(s)$	raising agent in food
Bath salt	magnesium sulphate	$MgSO_4(s)$	improve cleaning
Battery acid	sulphuric acid	$H_2SO_4(aq)$	car batteries
Household bleach	sodium hypochlorite	$NaOCl(aq)$	laundry bleach
Glucose	glucose	$C_6H_{12}O_6(s)$	energy source for organisms
Grain alcohol	ethanol	$CH_3CH_2OH(\ell)$ $C_2H_5OH(\ell)$	solvent, for manufacture of medicines, gasoline
Lime	calcium oxide	$CaO(s)$	mortar, steel and glass making, smokestack scrubbers
Limestone	calcium carbonate	$CaCO_3(s)$	cement and mortar, chalk, marble
Milk of magnesia	magnesium hydroxide	$Mg(OH)_2(s)$	antacid medication
MSG	monosodium glutamate	$C_5H_8NO_4Na(s)$	flavour enhancer
Muriatic acid	hydrochloric acid	$HCl(aq)$	tile cleaner, etching of masonry and marble surfaces
Natural gas	methane	$CH_4(g)$	fuel
PCBs	polychlorinated biphenyls	$C_{12}H_{10-n}Cl_n(\ell)$	electrical transformers
Peroxide	hydrogen peroxide	$H_2O_2(aq)$	antiseptic, disinfectant, bleaching agent
Potash	potassium chloride	$KCl(s)$	fertilizer
Road salt	calcium chloride	$CaCl_2(s)$	de-icing and dust control of roads
Silver nitrate	silver nitrate	$AgNO_3(s)$	antiseptic, photography, treatment of warts
Soda ash	sodium carbonate	$Na_2CO_3(s)$	glass, paper, and detergent production
Sugar	sucrose	$C_{12}H_{22}O_{11}(s)$	sweetener, preservative, food for yeast
Table salt	sodium chloride	$NaCl(s)$	flavour
Vitamin C	ascorbic acid	$C_6H_8O_6(s)$	production of connective tissue, antioxidant
Water	water	$H_2O(\ell)$	universal solvent, vital component of all organisms
Wood alcohol	methanol	$CH_3OH(\ell)$	antifreeze

Diagnostic Tests for Some Common Substances

Substance Detected	Description of Test
oxygen gas	Collect a small amount of gas in a test tube. Insert a glowing wooden splint into the test tube. If oxygen gas is present, the splint will ignite and you will see a flame.
hydrogen gas	Collect a small amount of gas in a test tube. Insert a burning wooden splint into the test tube. If hydrogen gas is present, you will hear a popping sound.
carbon dioxide gas	Collect a small amount of gas in a test tube. Insert a burning wooden splint into the test tube. If carbon dioxide gas is present, the flame will be extinguished (go out). Since other gases can also extinguish the flame, the presence of carbon dioxide must be confirmed by testing it with limewater (a solution of calcium hydroxide). Place a few drops of limewater into the test tube. If the gas is carbon dioxide, the limewater will turn milky.
bases	Dip a piece of red litmus paper into the solution. If the solution is a base (i.e., it has a $pH > 7$), the litmus paper will turn blue.
acids	Dip a piece of blue litmus paper into the solution. If the solution is an acid (i.e., it has a $pH < 7$), the litmus paper will turn red. Alternatively, add a drop of phenolphthalein indicator. If the solution is acidic, the indicator will be colourless or red. If the solution is not acidic, the indicator will be pink.

Common Polyatomic Ions

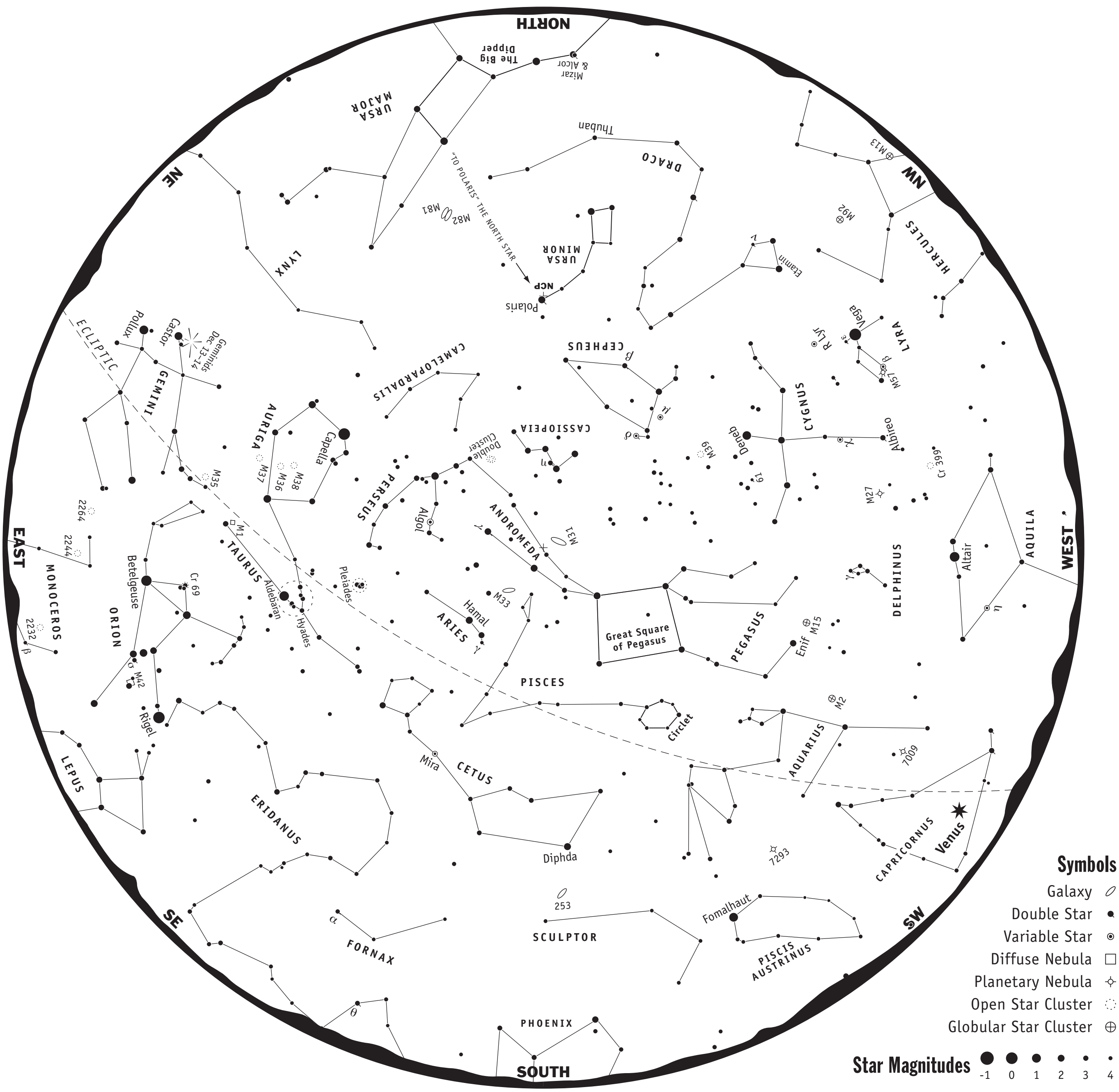
Polyatomic Ion	Formula
acetate	CH_3COO^-
ammonium	NH_4^+
borate	BO_3^{3-}
carbonate	CO_3^{2-}
hydrogen carbonate (bicarbonate)	HCO_3^-
chlorate	ClO_3^-
chlorite	ClO_2^-
hypochlorite	ClO^-
chromate	CrO_4^{2-}
dichromate	$Cr_2O_7^{2-}$
cyanide	CN^-
hydroxide	OH^-
nitrate	NO_3^-
nitrite	NO_2^-
perchlorate	ClO_4^-
permanganate	MnO_4^-
peroxide	O_2^{2-}
phosphate	PO_4^{3-}
phosphite	PO_3^{3-}
silicate	SiO_3^{2-}
sulphate	SO_4^{2-}
hydrogen sulphate	HSO_4^-
sulphite	SO_3^{2-}
hydrogen sulphite	HSO_3^-
hydrogen sulphide	HS^-

Electron Arrangements of the First 20 Elements

Atoms			Ions		
H	1 p	1	H^+	1 p	0
			H^-	1 p	2
He	2 p	2	He	does not form an ion	
Li	3 p	2, 1	Li^+	3 p	2
Be	4 p	2, 2	Be^{2+}	4 p	2
B	5 p	2, 3	B^{3+}	5 p	2
C	6 p	2, 4	C^{4-}	6 p	2, 8
N	7 p	2, 5	N^{3-}	7 p	2, 8
O	8 p	2, 6	O^{2-}	8 p	2, 8
F	9 p	2, 7	F^-	9 p	2, 8
Ne	10 p	2, 8	Ne	does not form an ion	
Na	11 p	2, 8, 1	Na^+	11 p	2, 8
Mg	12 p	2, 8, 2	Mg^{2+}	12 p	2, 8
Al	13 p	2, 8, 3	Al^{3+}	13 p	2, 8
Si	14 p	2, 8, 4	Si^{4-}	14 p	2, 8, 8
P	15 p	2, 8, 5	P^{3-}	15 p	2, 8, 8
S	16 p	2, 8, 6	S^{2-}	16 p	2, 8, 8
Cl	17 p	2, 8, 7	Cl^-	17 p	2, 8, 8
Ar	18 p	2, 8, 8	Ar	does not form an ion	
K	19 p	2, 8, 8, 1	K^+	19 p	2, 8, 8
Ca	20 p	2, 8, 8, 2	Ca^{2+}	20 p	2, 8, 8

Using a Star Chart

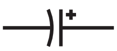
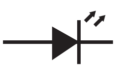
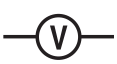
The Star Chart shown here will help you identify stars in the night sky.



Electricity Backgrounder

The table below is a handy reference for drawing electrical circuits. Remember that electricity is dangerous — be very careful when you use electricity at home or in the lab.

Symbols Used in Circuit Diagrams

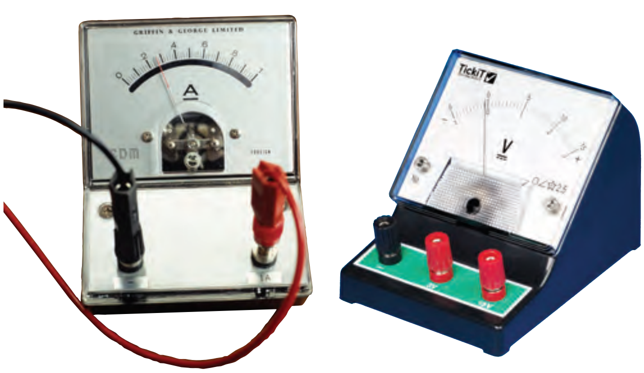
Symbol	Represents	Description
	ammeter	measures amount of current in circuit
	battery	combination of cells
	capacitor	stores electricity and regulates current
	cell	stores electricity (long bar is positive)
	conductor (wire)	conducts electricity through circuit
	connection	shows connection between wires in a circuit
	diode	converts alternating current (AC) to direct current (DC); only allows current to flow in one direction
	fuse	melts if current is too high
	lamp	converts electricity to light
	LED (light emitting diode)	diode that emits light (usually red) when current flows
	motor	converts electricity to mechanical energy
	photoconductor	allows current to flow when exposed to radiant energy (e.g., light, infrared)
	resistor	reduces the amount of current in the circuit
	rheostat	variable resistor
	speaker	converts electrical energy into sound energy
	switch	opens and closes circuit; allows current to flow
	voltmeter	measures voltage across a device in circuit

Electrical Safety in the Lab

- Handle batteries carefully because they contain acids or bases that can cause corrosive burns.
- Do not connect the two battery terminals with a wire or you will create a short circuit.
- Do not use bare connecting wires.
- Have your teacher check the circuit before you close the switch or connect the power source.
- Disconnect or turn off the power source before you connect wires in a circuit.
- Wear safety goggles when working with liquid electrolytes.

Measuring Current and Voltage

Current is measured using an ammeter while voltage is measured with a voltmeter. These devices are either digital display or analog display. Digital display meters show measurements as numbers, just as in a digital clock. Digital meters that combine both voltage and current measurements into one device are called multimeters. Analog meters use one or more dials and a pointing needle.

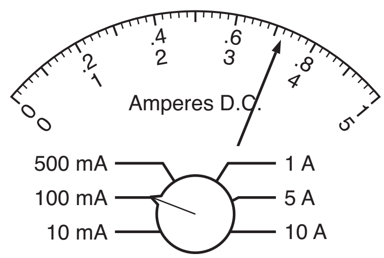


Analog ammeters and voltmeters use a pointer and a set of different scales.

Reading an Ammeter

Before an ammeter can be used, it must be correctly connected to the circuit. Since an ammeter measures the flow of electric current, it must be made part of the circuit so that the electric current will pass through it. To connect the ammeter, disconnect the circuit at the point where you wish to make a measurement and attach the wires so that the (+) side of the power source connects to the red terminal on the meter and the (–) side of the power source connects to the black terminal on the meter.

Reading a digital ammeter is straightforward, as the display will show the values directly. It may be possible to adjust the display to give more or fewer decimal places as desired. Reading an analog display ammeter involves noting the position of a pointer on a dial and reading the values from it. Many ammeters have two or even three scales. The choice of which scale is used is usually determined by which terminals on the ammeter are used to connect it into the circuit.

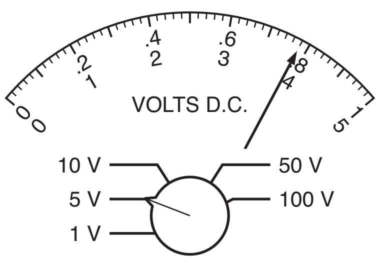


The ammeter above is connected using the 100-mA scale. This means that a full scale deflection of the pointer is 100 mA. Use the scale that has a full scale deflection of 1. This is 100 mA. Since the pointer is at 0.72, the reading is 0.72 mA.

Reading a Voltmeter

Before a voltmeter can be used, it must be correctly connected to the circuit. A voltmeter is used to detect the change in voltage across a device inside a circuit such as a resistor, light bulb, or dry cell. Do not disconnect any part of the circuit in order to connect a voltmeter. Connect two wires from the voltmeter to either side of the dry cell or other device where the voltage measurement is to be taken. Attach the wires so that the (+) side of the power source is closest to the wire from the red terminal on the meter and the (–) side of the power source is closest to the wire from the black terminal on the meter.

Reading a digital voltmeter is straightforward, as the display will show the values directly. It may be possible to adjust the display to give more or fewer decimal places as desired. Reading an analog display voltmeter involves noting the position of a pointer on a dial and reading the values from it. Like ammeters, many voltmeters have two or even three scales. The choice of scale used is usually determined by which terminals on the voltmeter are used to connect it into the circuit. Sometimes, a dial is used to select the appropriate scale, as in the example below.

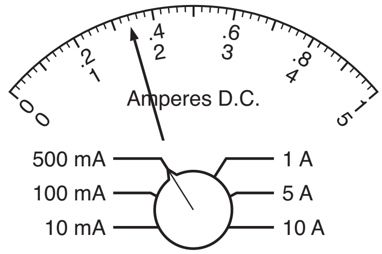


The voltmeter above is connected using the 5-V scale. This means that a full scale deflection of the pointer is 5 V. Use the scale that has a full scale deflection of 5. Since the pointer is at 3.9, the reading is 3.9 V.

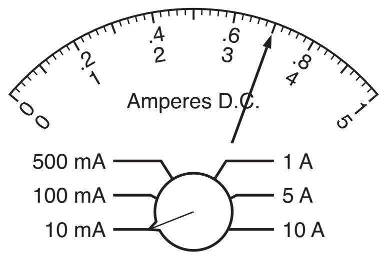
Instant Practice

1. Read the following meters and write their readings.

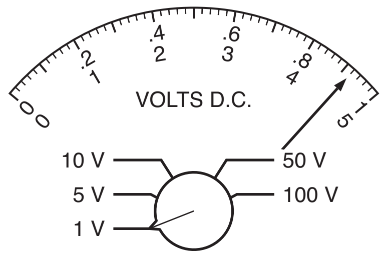
(a)



(b)



(c)



(d)