UNIT ONE

MEASUREMENT AND PRACTICAL WORK

INTRODUCTION

What is measurement?

- ✓ A measurement tells us about a property of something.
- ✓ It might tell us how heavy an object is, or how hot, or how long it is.
- ✓ A measurement gives a number to that property.
- ✓ Measurements are always made using an instrument of some kind. Rulers, stopwatches, weighing scales, and thermometers are all measuring instruments.

- There are some processes that might seem to be measurements, but are not.
- For example, comparing two pieces of string to see which is longer is not really a measurement. Counting is not normally viewed as a measurement. Often,

- A test is not a measurement: tests normally lead to a 'yes/no' answer or a 'pass/fail' result. (However, measurements may be part of the process leading up to a test result.)

What is Science?

Science is a methodical approach to studying the natural world.

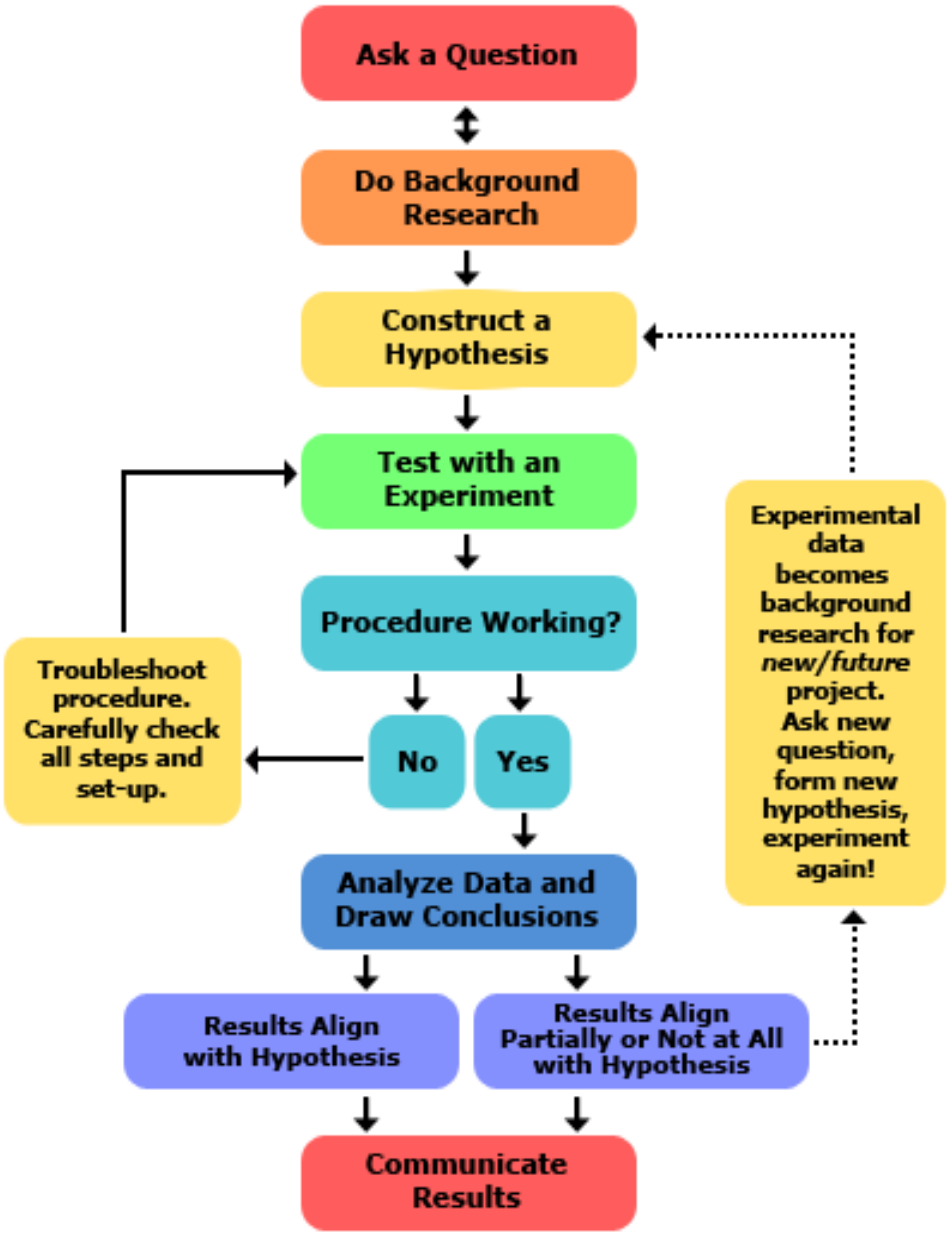
Science asks basic questions, such as:

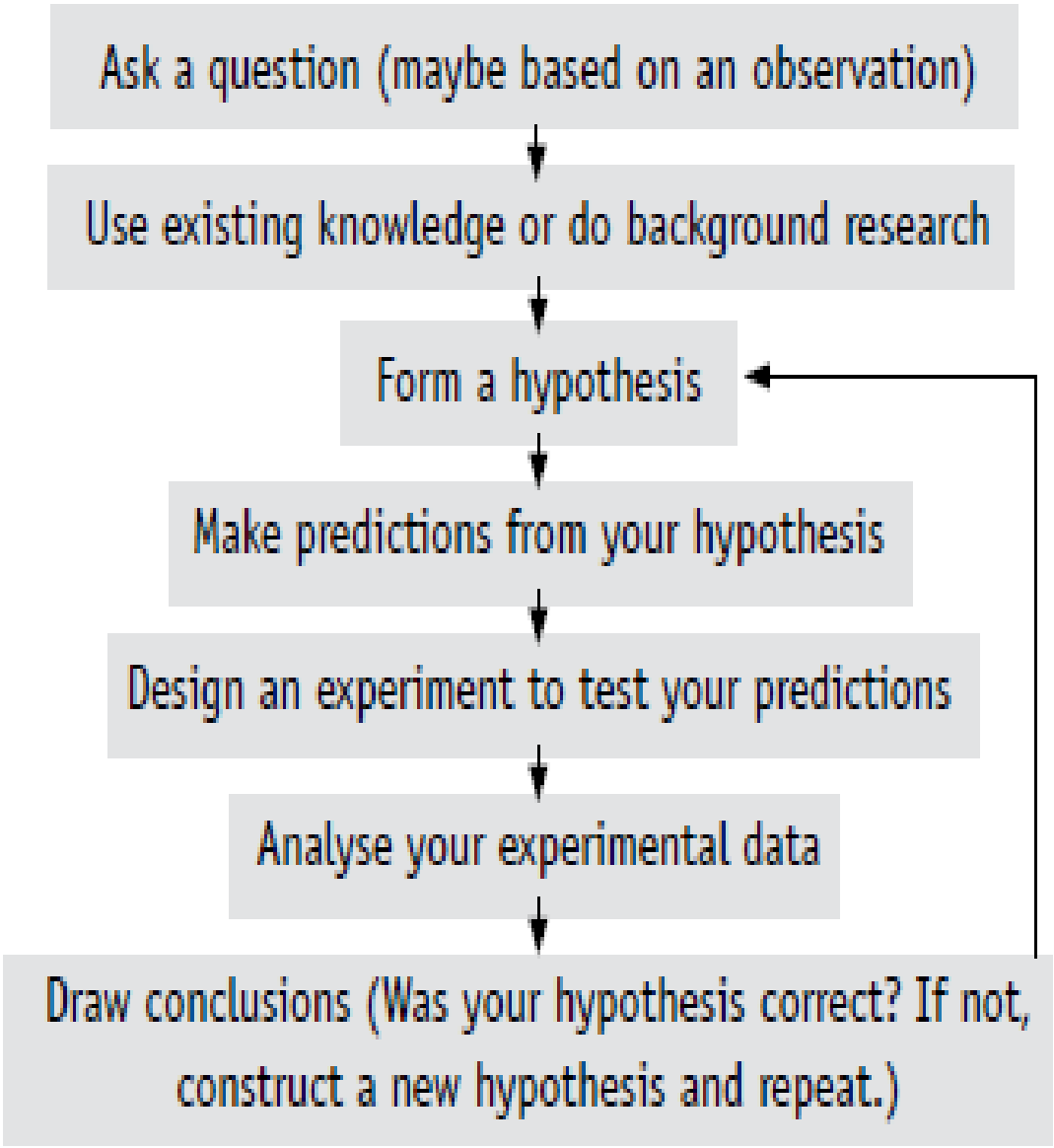
- How does the world work?
- How did the world come to be?
- What was the world like in the past, what is it like now, and what will it be like in the future?

These questions are answered using observation, testing, and interpretation through logic.

The scientific method

- The scientific method is a process for experimentation that is used to explore observations and answer questions.
- The scientific method is the process by which scientists, collectively and over time, endeavor to construct an accurate (that is, reliable, consistent and non-arbitrary) representation of the world.
- The scientific method is exceptionally important to the process of science.
- It ensures a rigorous, evidence-based structure where only ideas that have been carefully tested are accepted as scientific theory.


Ask a Question
Do Background Research
Construct a Hypothesis
Test with an Experiment
Procedure Working?
No
Yes
Troubleshoot procedure. Carefully check all steps and set-up.
Analyze Data and Draw Conclusions
Results Align with Hypothesis
Results Align Partially or Not at All with Hypothesis
Communicate Results
Experimental data becomes background research for *new/future* project. Ask new question, form new hypothesis, experiment again!


Ask a question (maybe based on an observation)
Use existing knowledge or do background research
Form a hypothesis
Make predictions from your hypothesis
Design an experiment to test your predictions
Analyse your experimental data
Draw conclusions (Was your hypothesis correct? If not, construct a new hypothesis and repeat.)

- **A hypothesis** is just an idea that might provide an answer to your question.
- A scientific hypothesis is based on scientific knowledge, not just made up!
- **Conclusions** are the overall result or outcome of an experiment. The hypothesis being tested may be supported by the results or may be proven incorrect.

Significant Figures

- All digits in a number that are not zero are called significant figures.
- In the measured value of a physical quantity, the number of digits about the correctness of which we are sure plus the next doubtful digit, are called the significant figures.

Rules for Finding Significant Figures

i. All non-zeros digits are significant figures,

e.g., 4362 m has 4 significant figures.

ii. All zeros occurring between non-zero digits are significant figures,

e.g., 1005 has 4 significant figures.

iii. All zeros to the right of the last non-zero digit are not significant,

e.g., 6250 has only 3 significant figures.

iv. In a digit less than one, all zeros to the right of the decimal point and to the left of a nonzero digit are not significant,

e.g., 0.00325 has only 3 significant figures.

v. All zeros to the right of a non-zero digit in the decimal part are significant, e.g., 1.4750 has 5 significant figures.

UNCERTAINITY

- Uncertainty is the amount of doubt in a measurement.
- It does not mean it is wrong; it is just a measure of your confidence in your measurement.
- Uncertainty is a critical piece of information.
- Uncertainty is a quantitative measure of how much your measured values deviate from a standard or expected value.
- If your measurements are not very accurate or precise, then the uncertainty of your values will be very high.

Example.

*If you were measuring the height of a friend, you might write:

1.70 m

Does this mean exactly 1.8 m? Does it mean

1.700000000000000000000000000000 m? When you write 1.70 m

You mean your friend's height is between 1.705 m and 1.695 m. You

Could write this as: 1.70 m ± 0.005 m

The 0.005 m is the uncertainty in your reading. You have measured the height to the nearest 5 mm. You should try to keep this

Uncertainty as small as possible.

The uncertainty in every measurement will be related to the nature

Of the task and the precision of the instrument you are using.

The factors contributing to uncertainty in a measurement include:

1. Limitations of the measuring device,
2. The skill of the person making the measurement,
3. Irregularities in the object being measured,
4. Any other factors that affect the outcome (highly dependent on the situation).

Percentage uncertainties

- This is just the uncertainty of the reading expressed as a percentage.
- It tell us the amount that we are not certain about measurement in percent.
- It is given by:

  Percentage uncertainty = $\frac{uncertainty}{measured\ value}$ x 100

Example

1. Find the percentage uncertainty

   i. $3.00A \pm 0.05A$

Solution.

Percentage uncertainty = $\frac{uncertainty}{measured\ value}$ x 100

% unc = $\frac{0.05}{3.00}$ x100

% unc = 1.66%

The it implies that

I= $3.00A \pm 1.66\%$

AVTIVITY 1

1. Describe each part of the scientific method. Explain why it is important to follow this structure when conducting a scientific investigation.
2. How many significant figures do the following numbers have:
   I. 258 b
   II. 0.2
   III. 12 000
   IV. 0.084
3. How can you reduce the percentage uncertainty in measurements that you make?
4. Nishan and Melesse have measured the voltage across a resistor to be 5.26 V and the current flowing through it to be 0.41 A. They work out the resistance. Nishan says that the resistance is 12.8 Ω. Melesse disagrees and says that the resistance is 13 Ω. Who is correct? Explain your answer.
5. A bulb is connected as part of a circuit. The following data is collected:
   Electric current: $3.2A \pm 0.1\ A$
   Potential difference: $12.3\ V \pm 0.1\ V$
   Use this data and the equation
   Resistance = $\frac{\text{potential difference}}{\text{electric current}}$ to determine the resistance.
   Express the uncertainty in your answer.