

Chapter 1

Introduction to science



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- 1.3 The Steps in a Scientific Investigation
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1.1 What is Science?



A. Natural Phenomena



1. Science is the **systematic study** of **nature** and its effects on us and the environment.
2. Hence, it is the study of natural phenomena.
3. Example of natural phenomena:
 - a. A baby growing up and becoming an adult,
 - b. An object falling to the ground,
 - c. Ice melting,
 - d. Lightning.
4. Science helps us understand natural phenomena. Discovering the answers to all natural phenomena leads us to new **scientific knowledge**.



B. The importance of science in everyday life



1. With scientific knowledge we can produce machines and appliances such as light bulbs, cars and computers.

2. The **application** of scientific knowledge is called technology.



3. Technology helps us to **progress** in every aspect of our lives as such:

- a. **Transportation**
- b. **Communication**
- c. **Agriculture**
- d. **Medicine**
- e. **Construction**



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C. Careers and Scientific Area of Study

1. Careers in science include the following:

a. **Doctor** - someone trained in medical science.



b. **Engineer** - person who designs, build and maintains engines, buildings or roads.



c. **Nurse** - a specialist in caring of patients



d. **Veterinarian**- an animal doctor.



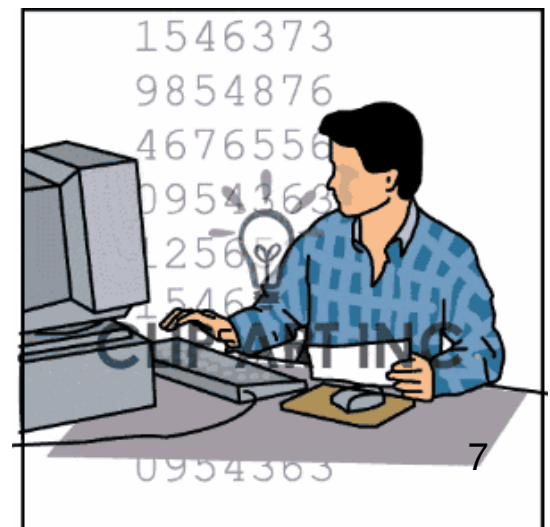
C. Careers and Scientific Area of Study

e. **Architect** - a person who design buildings.

f. **Pharmacist** - someone trained in the field of medicine and drugs.

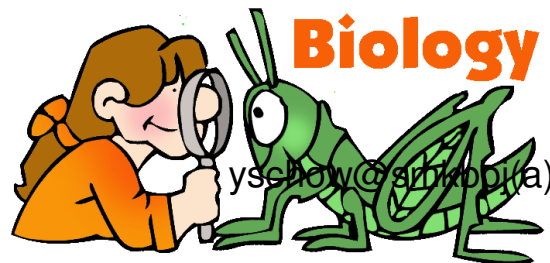
g. **Chemist** - someone trained in chemistry.

h. **Computer programmer** - a developer of computer software programmers.



2. The study of science is divided into various fields:

- a. **Astronomy** - study of planets and stars.
- b. **Biology** - the study of life.
- c. **Physics** - the study of matter and energy.
- d. **Physiology** - the study of processes and functions of systems in the human body.



2. The study of science is divided into various fields:

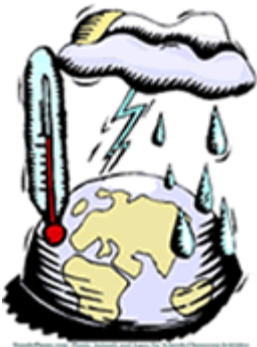
e. **Geology** - the study of rocks and minerals.

f. **Meteorology** - the study weather and climate.

g. **Chemistry** - the study of the composition and chemical properties of substances.

h. **Biotechnology** - the study of the industry trial use of living organisms.

i. **Biochemistry** - the study of chemical substances and chemical processes of living things.

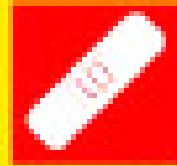


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1.2 A Science Laboratory

LAB SAFETY RULES



ALWAYS report accidents to the teacher or lab supervisor.



Read and understand the experiment **BEFORE** entering the lab.



Wash your hands and any lab instruments used before and after any lab activity.



Wear protective clothing. (Goggles, lab coat/aprons, hair tied back, close-toed shoes)



Be smart. No tasting, touching smelling unknown substances unless instructed to do so.



A. Discipline and Safety Rules in the Science laboratory

1. All pupils must follow safety rules and instruction from the teacher in the science laboratory.



2. Some examples of safety rules and precautions:

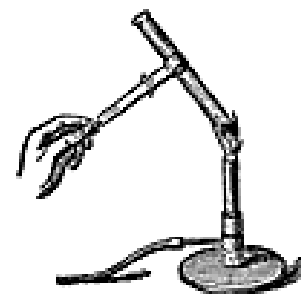
- a. No eating or drinking in the lab.
- b. Horseplay, practical jokes, and pranks are dangerous and prohibited.
- c. Observe good housekeeping practices.
Work areas should be kept clean and tidy at all






- d. Read the label on the bottle before using the chemical inside.
- e. Do not stand too close to the flame when heating up a solution.
- f. Never point the mouth of the boiling tube towards anybody when heating.
- g. Tie your hair neatly when doing experiments.



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Hazard warning symbols

Symbols	Meaning	Examples
 Corrosive	* Damages the skin and eyes upon contact.	* Concentrated sulphuric acid * Concentrated sodium hydroxide
 Flammable	* Burns easily.	* Petrol * Alcohol * Kerosene
 Poisonous	* Causes death or harm if absorb through the skin, swallowed or inhaled.	* Mercury * Sodium cyanide

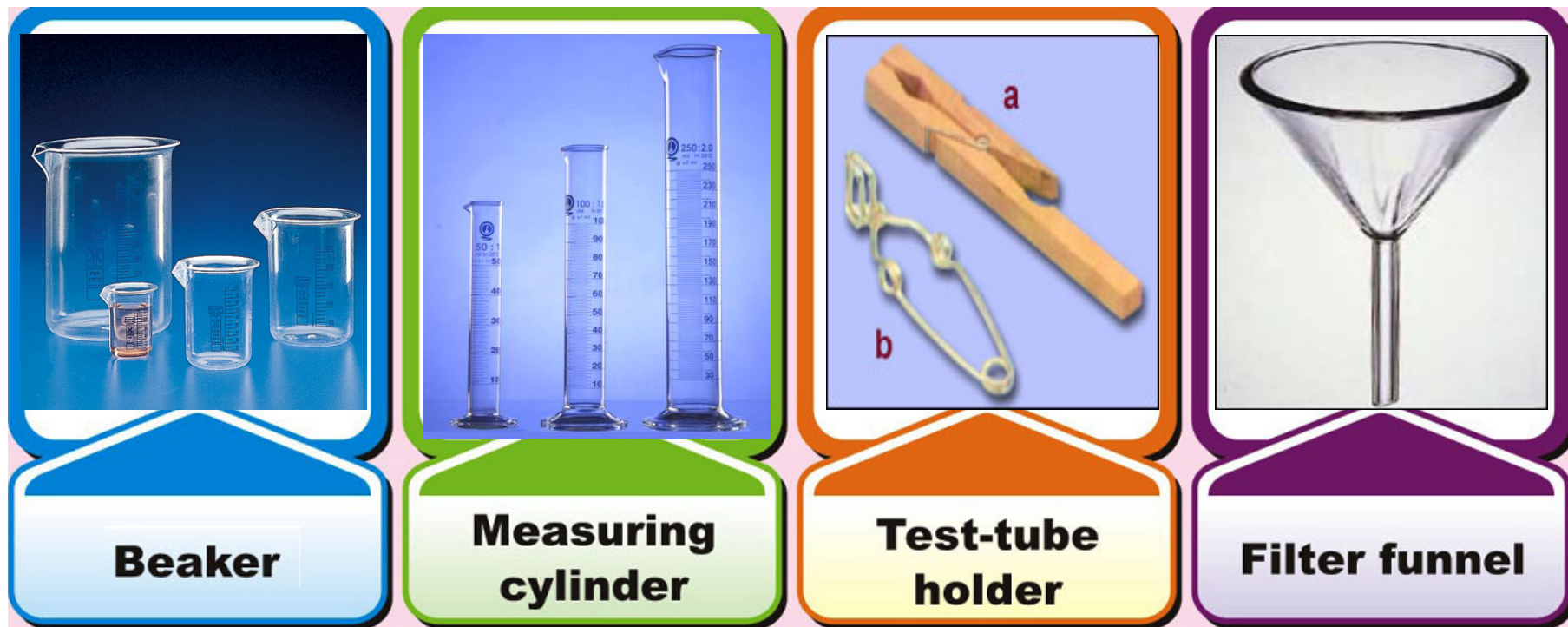
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Hazard warning symbols

Symbols	Meaning	Examples
 Explosive	* Explodes easily.	* Potassium * Sodium
 Irritant	* Causes discomfort to the body.	* Chloroform * Ammonia * Bromine vapour
 Radioactive	* Gives out radiation.	* Uranium * Plutonium * Radium

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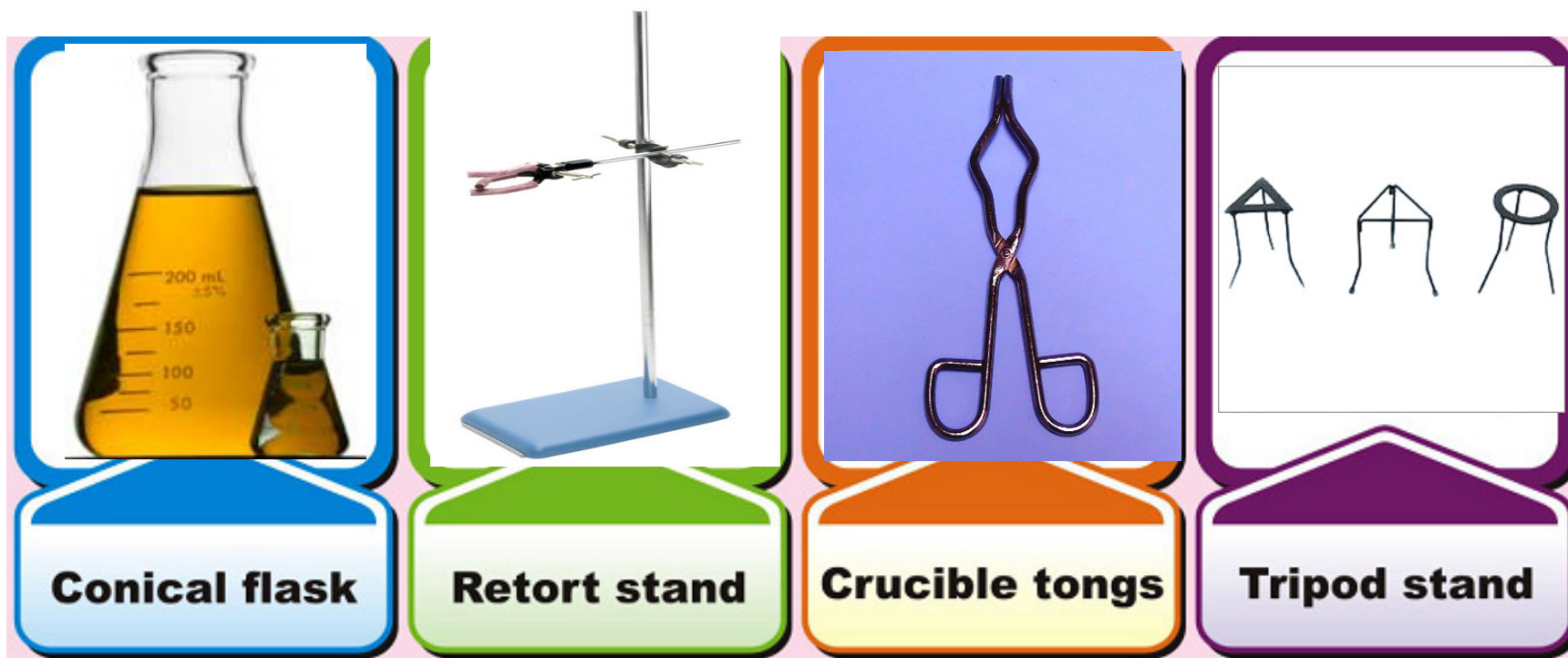
Some common apparatus in the school laboratory



Some common apparatus in the school laboratory



Some common apparatus in the school laboratory

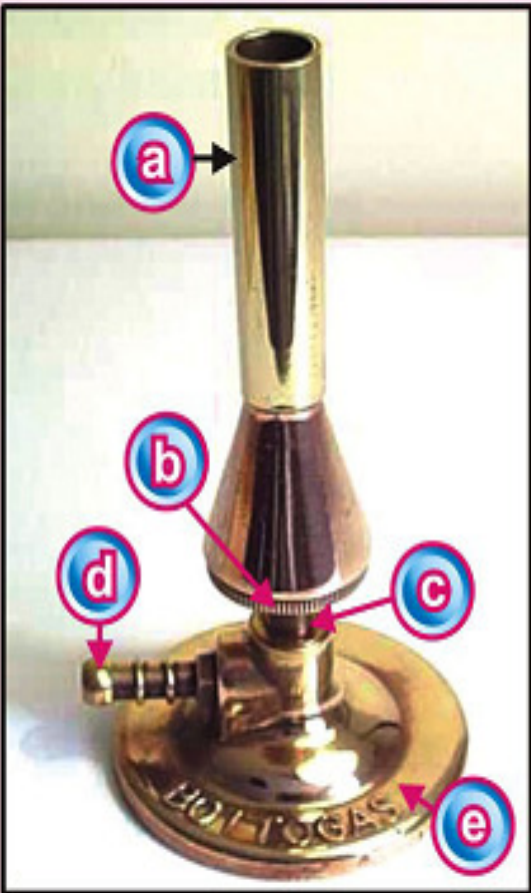


Crucible

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The Bunsen burner

Parts	Functions
a. Barrel	To allow air and gas to mix.
b. Collar	To control the size of the air-hole.
c. Air-hole	To allow air to enter.
d. Gas inlet	Passage for gas to enter.
e. Base	To stabilize the Bunsen burner



1.3 The Steps in a Scientific Investigation



A. Method of acquiring scientific knowledge.

1. Scientific investigation is a **systematic method** of studying a problem or an event.
2. It involves using **science process skills**.
3. Through scientific investigation, we get scientific knowledge.

Steps in a scientific investigation



```
graph TD; A[Steps in a scientific investigation] --> B[1. Identifying the problem]; B --> C[2. Forming a hypothesis]; C --> D[3. Planning the experiment (investigation)]; D --> E[4. Controlling the variables]; E --> F[5. Collecting data];
```

1. Identifying the problem

2. Forming a hypothesis

3. Planning the experiment (investigation)

4. Controlling the variables

5. Collecting data

6. **Analysing data**

7. **Interpreting data**

8. **Making conclusions**

9. **Writing a report**



An **experiment** (ik SPER uh ment)
is a scientific investigation that
tests a hypothesis (hy PAHTH ih sis).

Identify the problem



- **Not all questions are scientific questions**
- **This is not a scientific question because "big" and "small" mean different things to different people.**
- **This is a scientific question because you can measure the depth of the puddle**

Forming a Hypothesis

A hypothesis is an idea that can be tested by an experiment or an observation.



Example:

Hypothesis:

Swing with shorter length, swing faster.

Variable :

Time

(Your variable is testable.

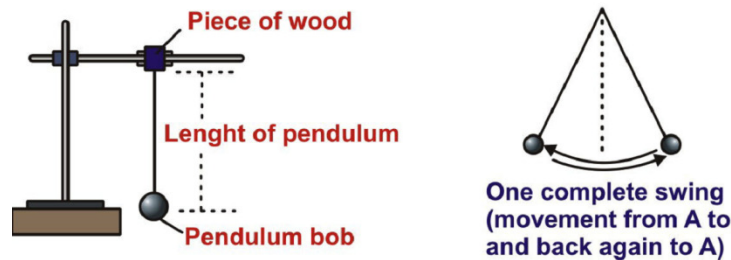
You can use stopwatch
to get the time)

For many science activities you do in school, you will not need to make a hypothesis. That's all right. Not every scientific investigation involves a hypothesis or even an experiment.



Planning the investigation

- Before you begin your investigation, **list the steps** you will follow
- Decide **what equipment** you will need for your investigation and where you can get it.



careful
planning
makes an
investigation
run smoothly

Example:

1. Set up a simple pendulum as shown above.
2. Pull the pendulum to one side and release it to swing.
3. Record the time taken for pendulum to make 10 complete swings.
4. Repeat step 1 to 3 with different length.

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Controlling Variables (*pembolehubah* 变数)

- A variable is any factor that can change in an experiment.

Example :

Constant (fixed variable)

1. Weight of pendulum bob
2. Number of swings

Manipulated variable

Length of variable

Responding variable

Time for 10 swings

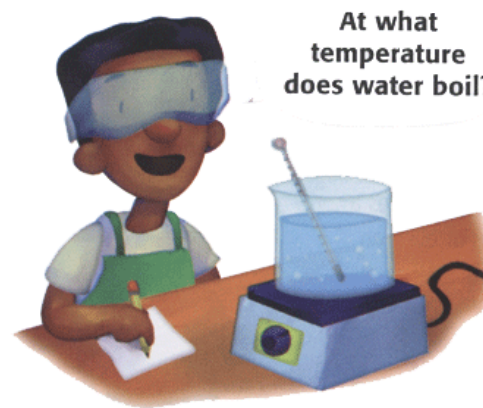


Unscientific

Scientific

Collecting data

- Every investigation gives you information. The pieces of information collected in an investigation are called data. There are many kinds of data. Some data are simple observations. Other data are measurements.



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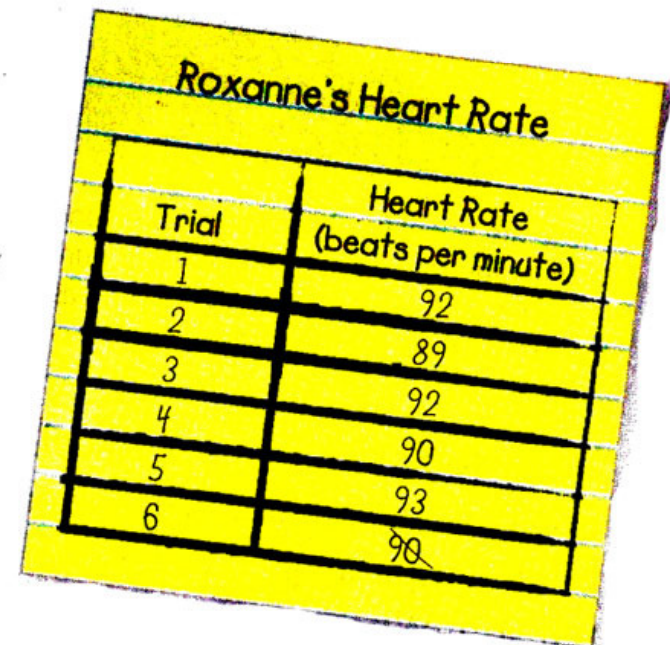


Analyzing data

- A trial is a **repeat of a test or an observation**.
- The more trials you do, the more you can trust the data that you collect.

Example :

Repeat step 2-3 to obtain one more reading.



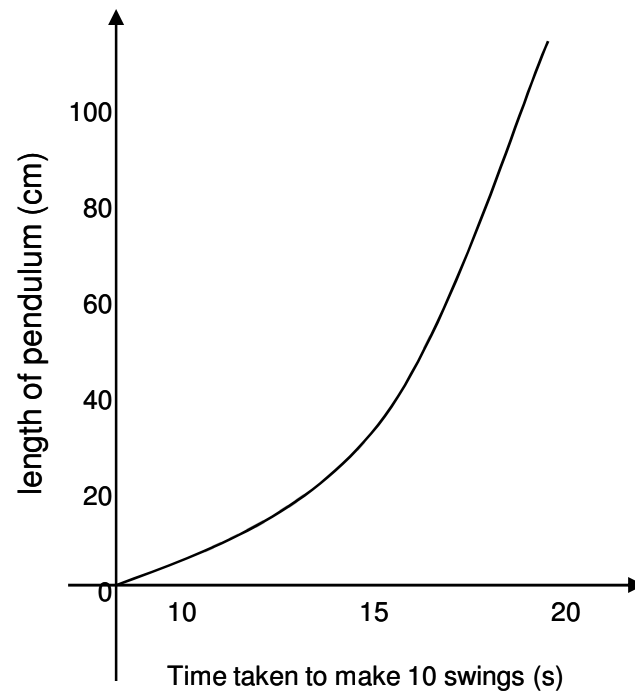
Trial	Heart Rate (beats per minute)
1	92
2	89
3	92
4	90
5	93
6	90

Interpreting Data

- Arrange the data to make it clear and easily to understand.

Example :

Plot a graph of length of pendulum against the time taken for 10 swings



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Making conclusion

- **Comparing** Your Data With Your **Hypothesis**.
- If your data do not support your hypothesis check for errors in your experiment. If you do not find any errors, your hypothesis was incorrect.

Example:

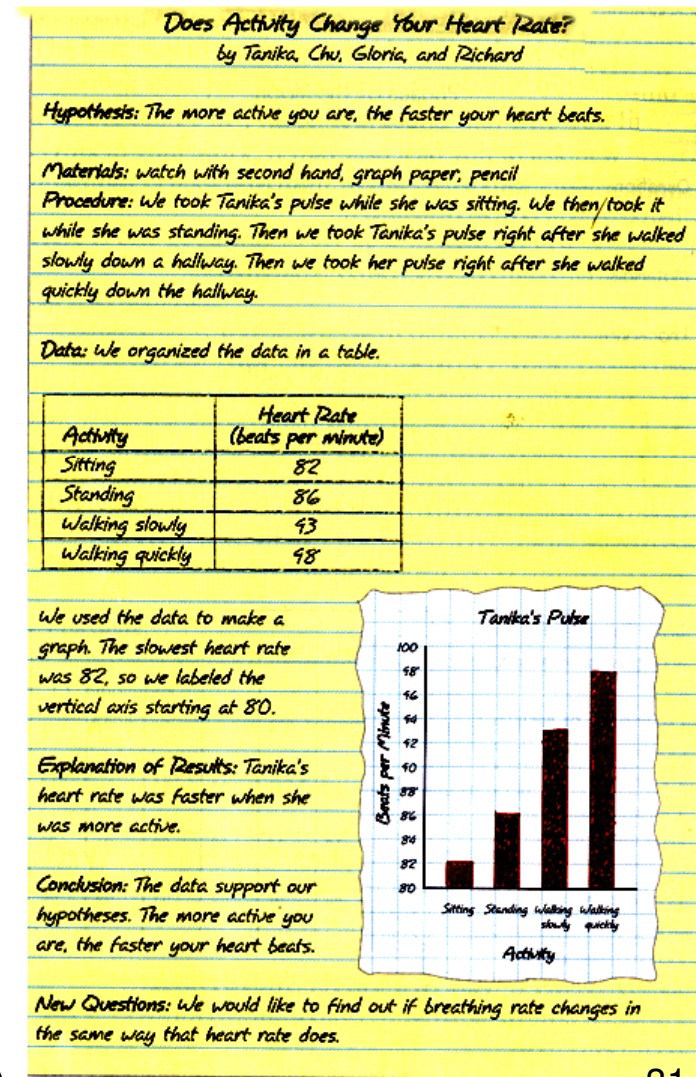
The hypothesis is accepted.

As the length of the pendulum decreases,
the pendulum swing faster.



Writing report

- The best way to share your work is to write a report that describes what you did and what you found out.
- Writing a report can be helpful to you, too. It may help you find errors in your work. It may also lead you to ask new questions. These questions might spark new investigations.



1.4 Physical Quantities and Their Units



A. Measurement of Physical Quantities.

1. A **physical quantity** is a quantity that can be **measured**.
2. Measurement is an important steps and a skill for **collecting data** during an investigation.
3. Physical quantities are measured in **S.I. units**.
 - a. S.I. units means *International System of Units*.
 - b. S.I. symbol is an abbreviation for the French term *Systeme International d'Unites*.

4. Base quantities.

Physical quantity	Symbol	S.I unit	Symbol (S.I unit)	Instrument
Length	l	metre	m	Metre rule
Mass	m	kilogram	kg	Lever or beam balance
Time	t	second	s	Stopwatch
Temperature	T	Kelvin	K	Thermometer
Electric current	I	ampare	A	Ammeter

b. Length (*panjang* 长度)

- i. The unit **metre** is used for measuring length.
- ii. Long distance such as the distance between two towns are measured in **kilometres**.



c. Time (*masa*, 时间)



- i. Time is measured in **seconds**.
- ii. Other units for time are minutes, hours, days, weeks and months

d. Mass (*Jirim*, 质量)

- i. Mass is **the total content of matter in an object**.
- ii. Mass is measured in **kilogram**.
- iii. Small masses are usually measured in **grams** or **milligrams**.
- iv. Large masses are measured in **tonnes**.



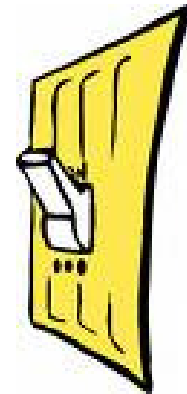
e. Temperature (*suhu*, 温度)



- i. Temperature is the degree of hotness or coldness.
- ii. The S.I. unit for temperature is **Kelvin**.
- iii. Other units for temperature are the metric unit degrees Celsius or degrees Fahrenheit.
- iv. Our body temperature is measured using a clinical thermometer.
The scale on the thermometer from 32 °C to 42°C.

f. Electric current

- i. Electric current is the flow of electrons.
- ii. It is measured using an ammeter.
- iii. Electric current is measured in **ampere**.



B. Prefixes used in measurement

1. Prefixes are useful in **expressing** physical quantities that are either too big or too small.
2. For example, the thickness of a book is measured in centimetres where centi- is the prefix added to metre to express a **smaller** value.
3. A prefix is added to change the value of the unit.
4. Hence, the value of any physical quantity can be changed to prefix form.

3. Symbol and prefixes

Prefix	Symbol	Numerical value
Tera-	T	1 000 000 000 000
Giga-	G	1 000 000 000
Mega-	M	1 000 000
Kilo-	k	1 000
Hecto-	h	1 00
Deca-	da	1 0
Deci-	d	0.1
Centi-	c	0.01
Milli-	m	0.001
Micro-	μ	0.000 001
Nano-	n	0.000 000 001
Pico-	p	yschow@smkbpj(a) 0.000 000 000 001

Work examples

a. Example 1

Write 950 000 g with the kilo prefix.

Answer:

$$\frac{950\,000}{1\,000} = 950\text{ kg}$$



b. Example 2

Change 230 cm to mm.

Answer: 230 cm

$$230\text{ cm} \times 10 = 2300\text{ mm}$$

6. Some physical quantities and their values in prefix form.

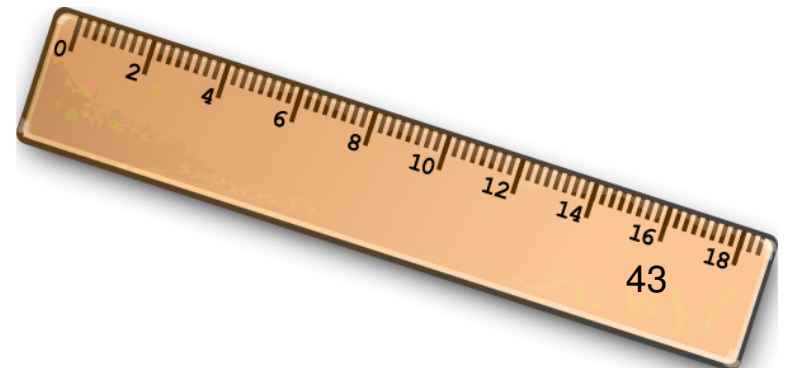
Value of physical quantity	Prefix form
0.005 m	5 mm
250 g	0.25 kg
4 000 000 K	4 MK
0.000 003 A	3 μ A
9 000 000 g	9 Mg or 9 000 kg

1.5 Measuring Tools

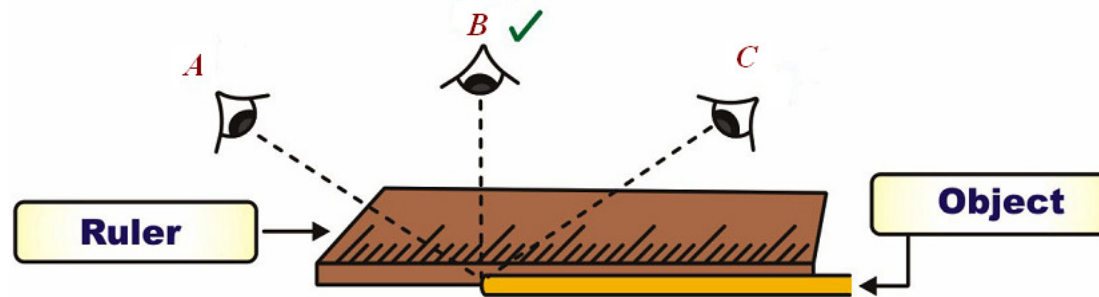


A. Measurement of Length

1. Length is the **distance** between **two points**.
2. The length of an object can be measured using a metre rule.
3. The length of a metre rule is one metre.
4. The scale on the metre rule is in centimetres and millimetres.
 - a. 10 millimetres (mm) = 1 centimetre (cm)
 - b. 100 centimetres (cm) = 1 metre (m)



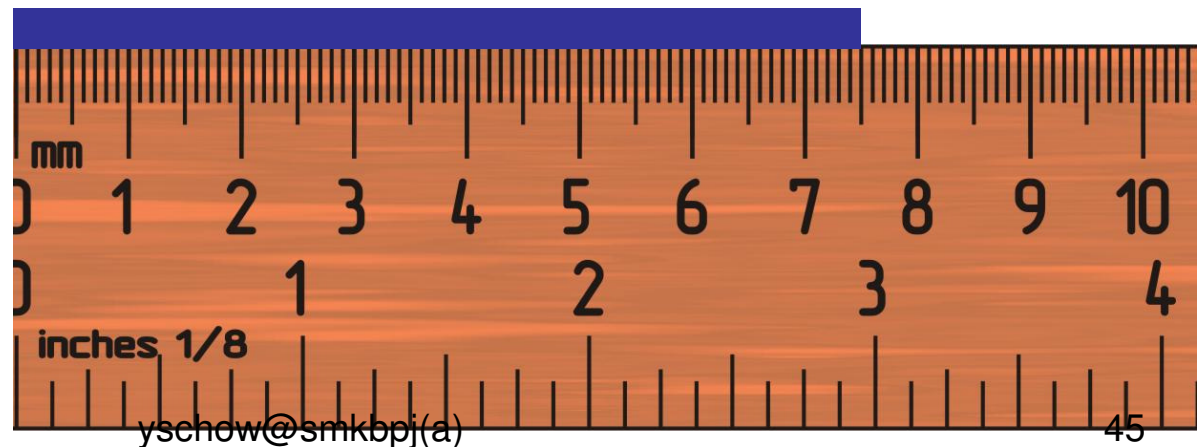
Measuring the length of an object:



- a. The ruler is placed at the side of the object to be measured.
- b. To take a reading, your eye needs to be **vertically above** the end of the object (position B) as shown in Figure.
- c. If the position of the eye is at A or C, the reading taken is **not accurate**.
- d. This error is known as **parallax error**.
- e. The length is measured by taking several readings and the **average length** is then determined.

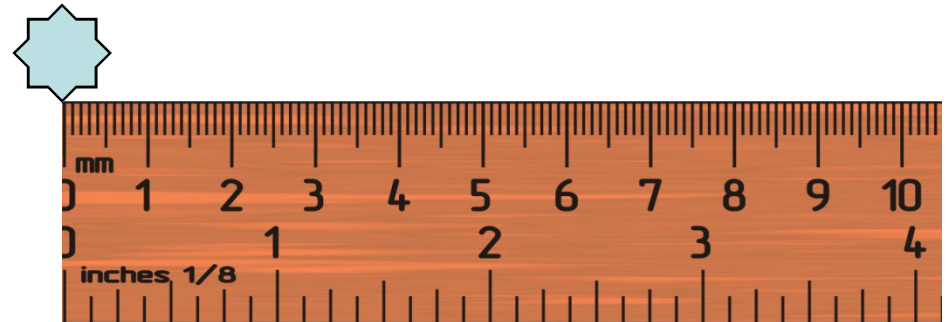
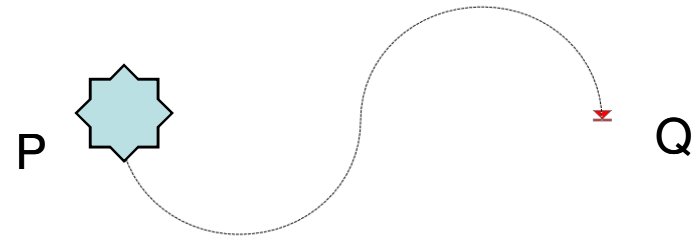
Measuring the length of a curve:

- Some **thread** and a ruler are used for measuring the length of a curve.
- The thread is placed along the length of the curve PQ. The end of the curve is **marked** on the thread.
- The length of the thread is later measured using the metre rule.
- The length of the curve is measured three times. Then the average length is determined.



Measuring the length of a curve:

- e. The length of the curve PQ can also be measured using an **opisometer** and a metre rule.



Measuring the diameter of an object

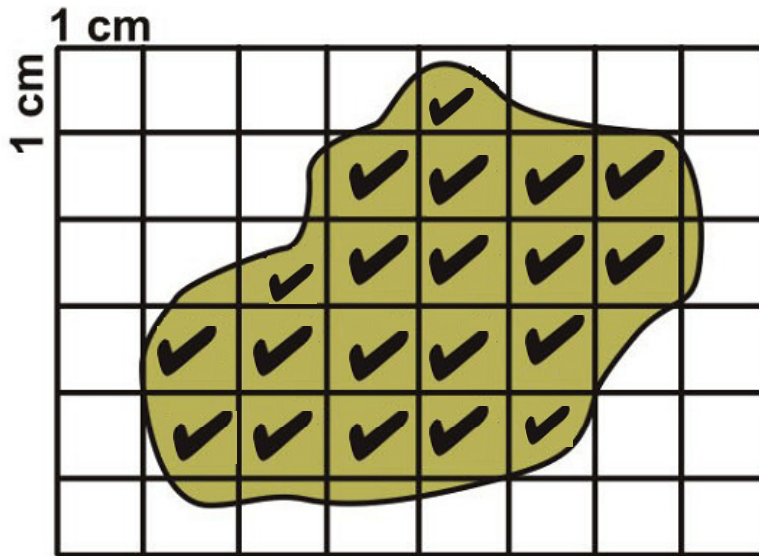
- a. The **inner** and **outer** diameters of round objects can be measured using **calipers** and a ruler.
- b. **External calipers** are used to measure the external diameter of the object.
- c. **Internal calipers** are used to measure the internal diameter of the object.



B. Measurement of Area (*Luas*, 面积)

1. The S.I. unit for area is square metres (m^2).
2. A huge area can be measured in square kilometres whereas for smaller areas are measured in square centimetres (cm^2) and square millimetres (mm^2).
 - a. $1 \text{ m}^2 = 10\,000 \text{ cm}^2$
 - b. $1 \text{ cm}^2 = 100 \text{ mm}^2$
3. The area of objects with regular shapes are calculated using mathematical formulae.
4. The area of irregular-shaped objects can be estimated by using graph paper

Estimating area of irregular-shaped objects

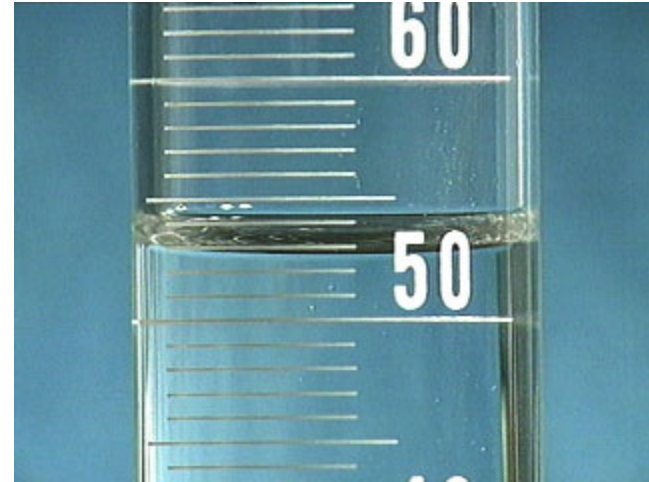
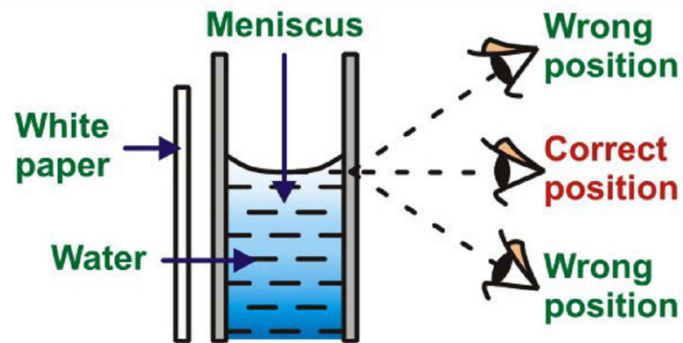


- The shape of the object is traced on a graph paper.
- Tick (✓) for every **complete square** (measuring 1 cm^2) covered by the object.
- Then tick (✓) the squares where the area is **half or more than half** the area of the square.
- The **total number of (✓)** on the graph paper for the shape **is counted**.

C. Measurement of Volume

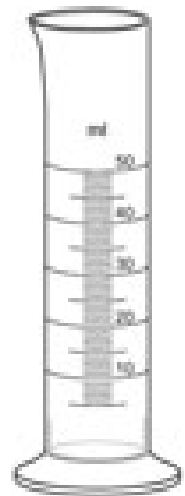
1. The S.I. unit for volume is cubic metres (m^3).
2. Other units for volume is cubic millimetres (mm^3), cubic centimetres (cm^3), millilitres (m l) and litre (l).
 - a. $1 \text{ cm}^3 = 1 \text{ m l}$
 - b. $1 \text{ l} = 1\,000 \text{ ml (cm}^3\text{)}$
 - c. $1 \text{ m}^3 = 1\,000\,000 \text{ cm}^3 (\text{m l})$
3. All these units can be used to measure the volume of liquids.
4. The volume of liquids is usually measured in litre and millilitre.
5. The volume of solids is measured in cm^3 and m^3 units.

Measuring volume (*Isipadu*, 体积)



a. Using a **measuring cylinder**.

- The measuring cylinder must be placed on a flat surface.
- The level of the liquid in a measuring cylinder is **curved downwards**. This curve is called the **meniscus**.
- Except for mercury, the meniscus is **curved upwards**.
- When reading the volume, the reading should be taken at the same level as the bottom of the meniscus.
- The correct eye position prevents parallax error.

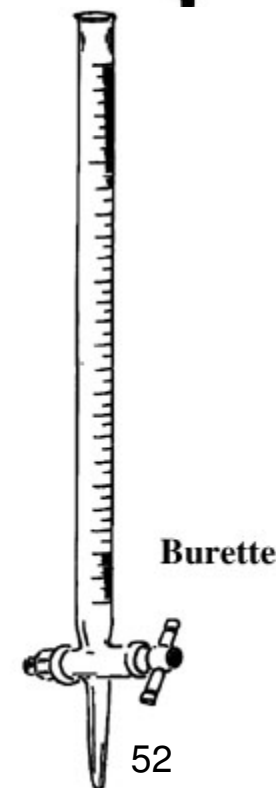


b. Using a pipette (移液管)

- i. Water is carefully sucked into the pipette until the bottom of the meniscus is at the same level as the 25 ml mark.
- ii. The volume of water that is sucked in is 25 ml.

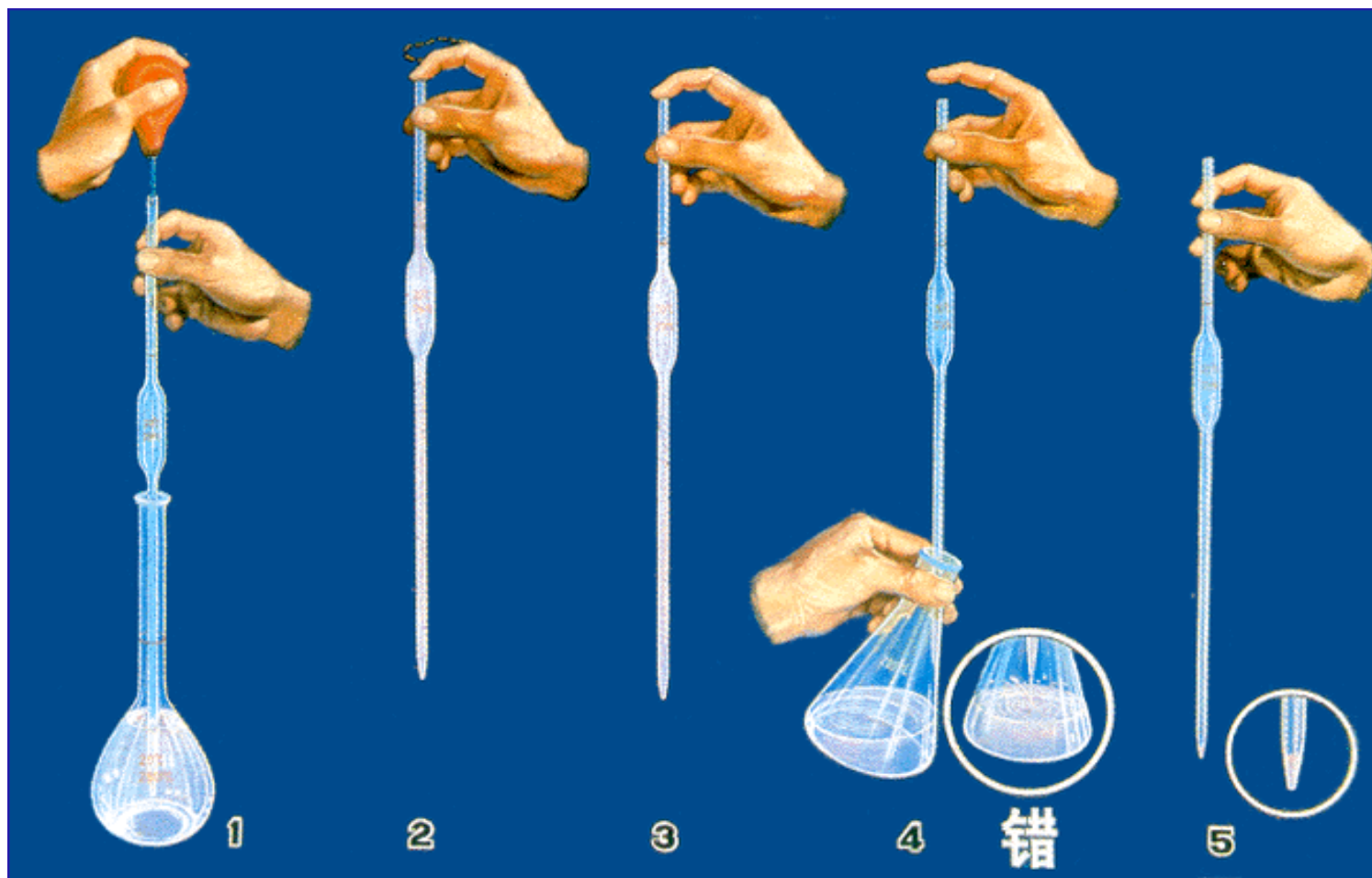
c. Using a burette (滴定管)

- i. A burette is clamped vertically retort stand.
- ii. Water is poured into the burette through a filter funnel.
- iii. The burette reading is recorded.
- iv. The burette clip is opened and water flows into the beaker.
- v. The burette clip is closed.
- vi. The new water level is recorded.
- vii. The volume of water is obtained by noting the difference between the final and the initial readings of the burette.



Using a pipette

移液管的使用

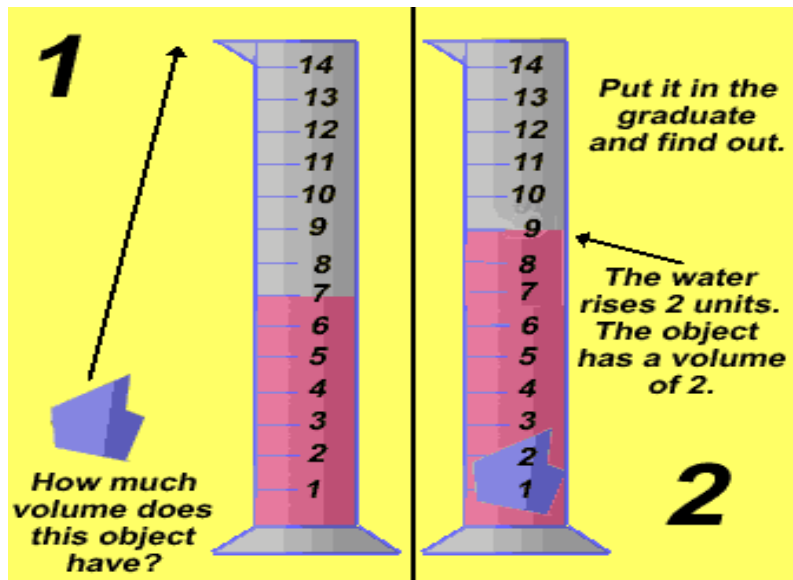


1. 吸溶液：右手握住移液管，左手掀洗耳球多次。2. 把溶液吸到管颈标线以下，不时放松食指，使管内液面慢慢下降。3. 把液面调节到标线。4. 放出溶液：移液管下端紧贴锥形瓶内壁，放开食指，溶液沿瓶壁自由流出。5. 残留在移液管尖的最后一滴溶液，一般不要吹掉（如果管上有“吹”字，就要吹掉）。

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7. Measuring the volume of solids

- a. The volume of regular solids and irregular solids can be measured by using the **water displacement method**.
- b. The **eureka tin** can also be used to measure the volume of regular and irregular solids.



water displacement method

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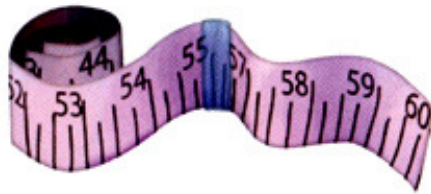
D. Choosing suitable measuring instruments

1. Accuracy

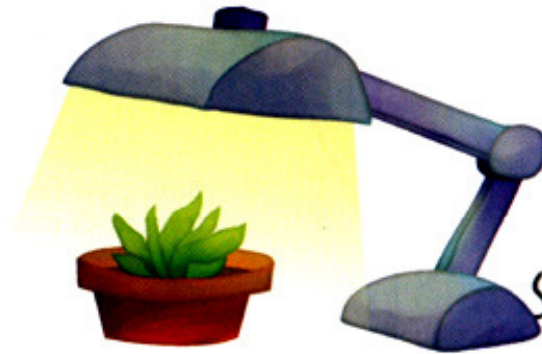
- a. The accuracy of a measurement is **how close** the measured value is to the **real value**.
- b. The difference between the measured value and the real value is the **error** in the reading.
- c. A more precise or accurate measuring instruments will have smaller errors.
- d. The accuracy of a measurement can be improved by calculating the **average** of the several readings taken.

How Good Are These Data?

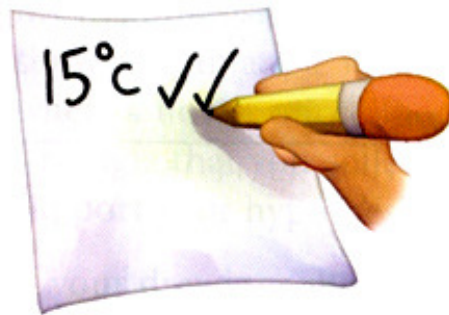
- Damaged tools can give you inaccurate data. For example, a damaged tape measure may not measure length accurately. Here are some tips for getting accurate data.



Tools: Tools that don't work well can produce bad data.

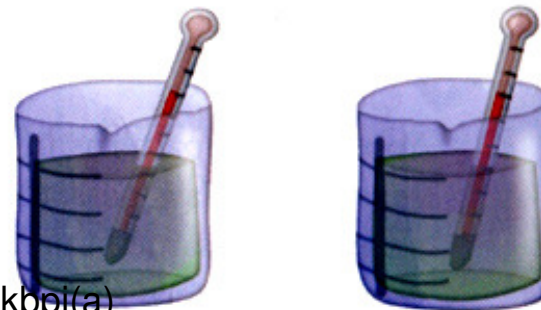


Variables: If you are performing an experiment, make sure you are changing only one variable, such as light.



Record: Record your data right away. If you wait until later, you might forget what you observed.

Double-Check: Double-check all your measurements.



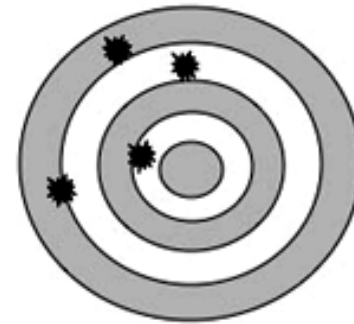
Trials: Repeat the investigation.

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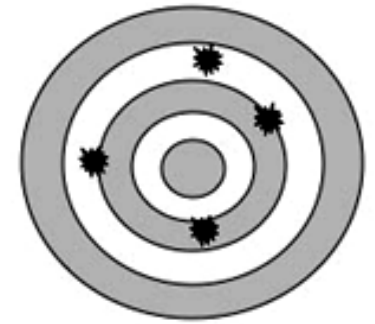
D. Choosing suitable measuring instruments

2. Precision

- a. Precision is the difference in values between **several measurements** obtained in the **same way**.
- b. A very high precision means one set of measurements differ very slightly from the average reading.
- c. Precision in measurement can be improved if a more precise measuring instrument is used.



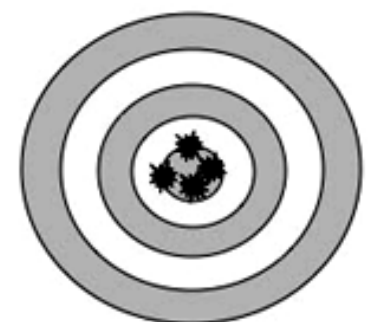
Not Accurate
Not Precise



Accurate
Not Precise

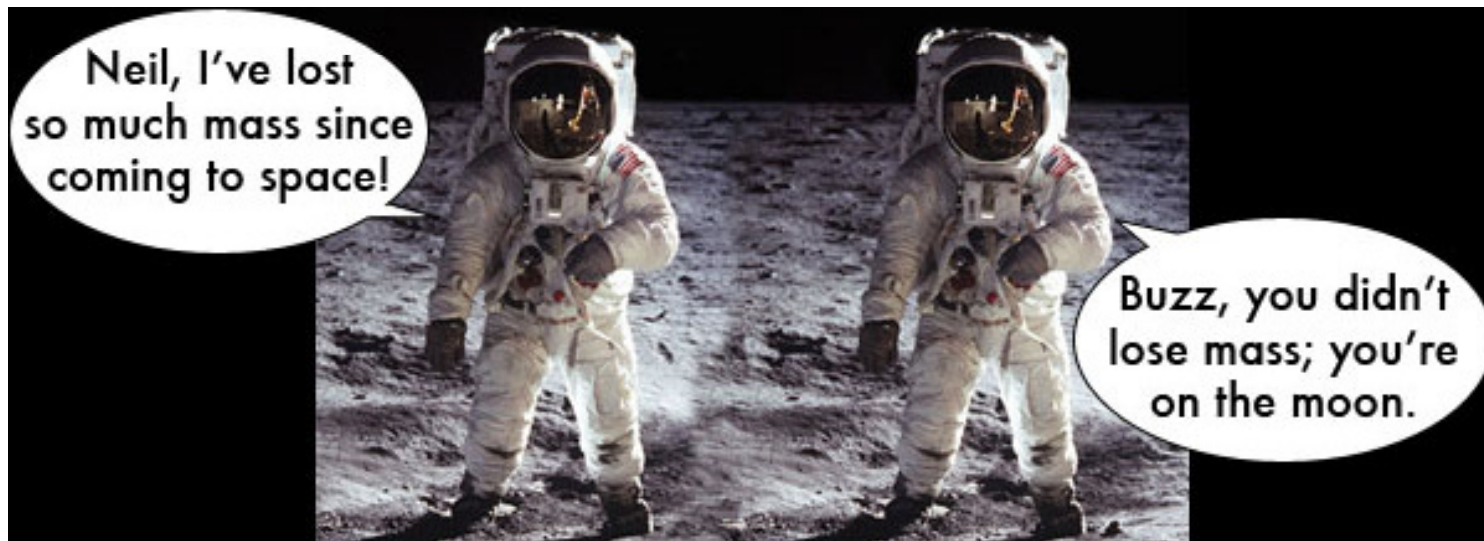


Not Accurate
Precise

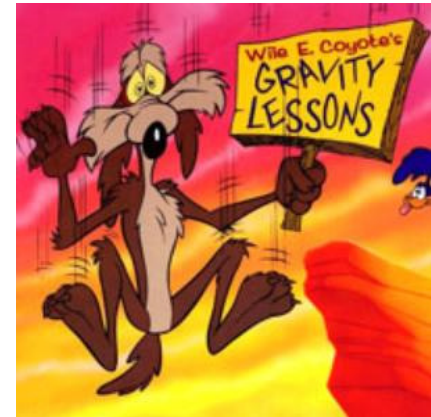


Accurate
Precise

1.6 Weight and Mass

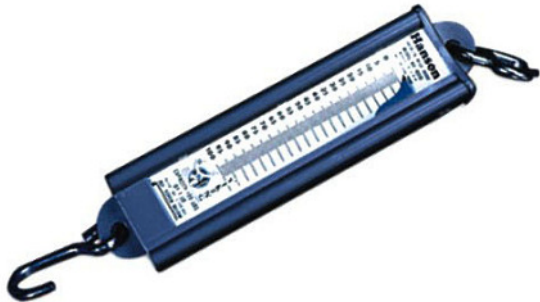


A. weight



1. Earth's gravity pulls all objects to its centre.
2. The weight of an object is a **result** of the **force of gravity**.
3. The weight of an object is **not constant** . It changes from one place to another depending on the force of gravity.
4. The weight of an object is **greater** at the poles than at the equator.

5. The weight of an object can be measured using a **spring balance** or a **compression balance**.
6. The S.I. unit for measuring weight is **newton (N)**.
7. One newton is almost equal to **one tenth ($1/10$)** of a **kilogram-force**.



Spring balance



Compression balance

yschow@smkbpj(a)

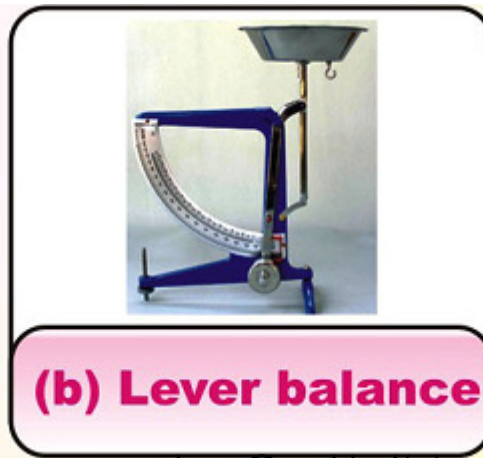
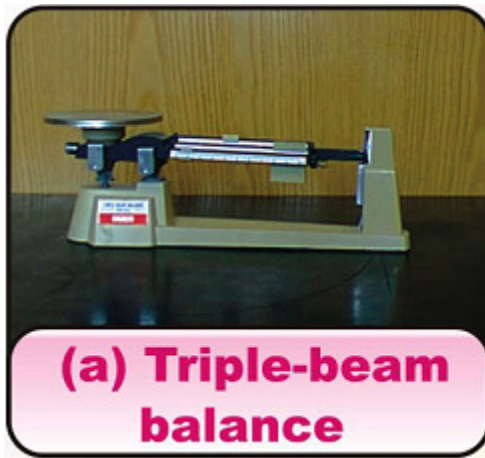
The concept of mass

1. Mass is the quantity of matter contained in an object.
2. The mass of an object does not change because the quantity of matter contained in it is the **same** wherever the object is.



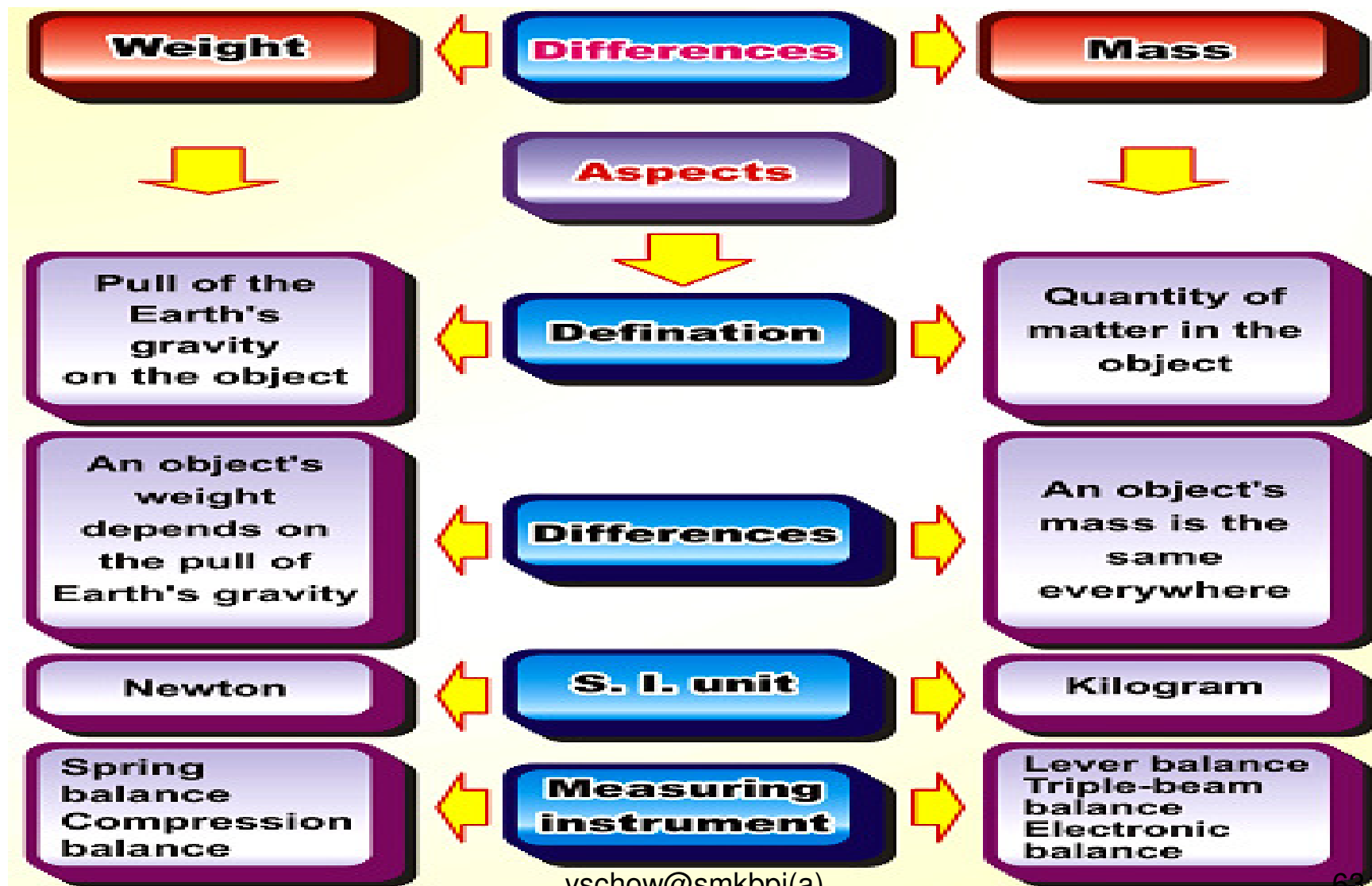
*My mass on the moon is
same as on the Earth.*

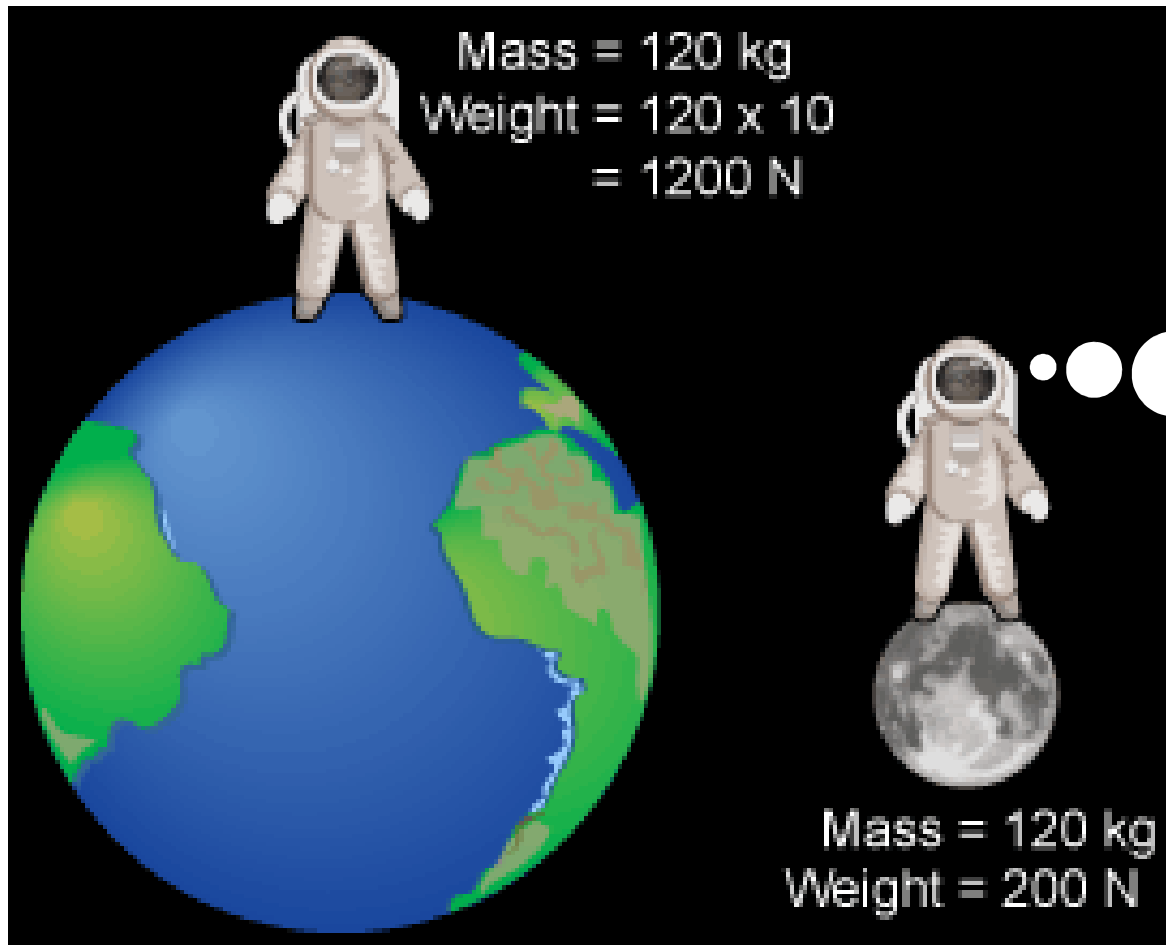
3. The **lever balance** or the **beam balance** is used to measure the mass of an object.
4. A more accurate measurement of measurement of mass is obtained by using an **electronic balance**.
5. The S.I. unit for mass is kilogram (kg).



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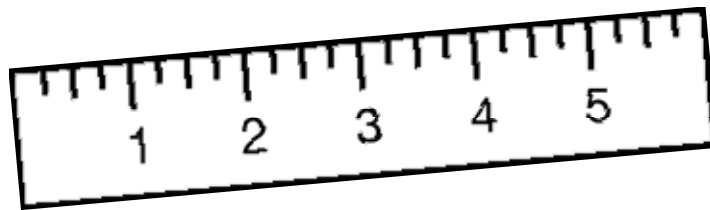
Differences between weight and mass





Gravitational
force of moon is
 $\frac{1}{6}$ of earth.

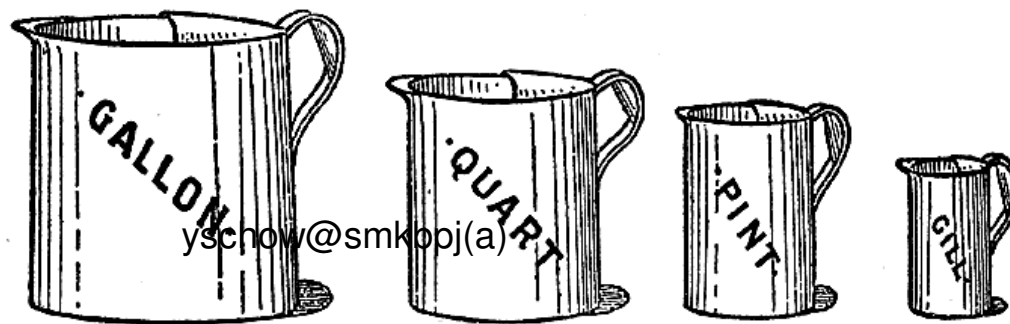
Therefore,
my weight
become
 $\frac{1}{6} \times 1200$
= 200 N



1.7

THE IMPORTANCE OF STANDARD UNITS

- A. standard system of units is important to create better understanding between countries in trading, international transportation and scientific research.
- B. Before S.I. units were introduced in 1960, other systems of standard units were used such as the system of foot-pound-second (FPS).
- C. The metric system of measurement is now a common standard of measurement and it is used as S.I. units.



1. Other systems of standard units can be converted to S.I. units and vice versa:

a. 1 inch = 2.54 cm

b. 1 foot (12 inches) = 30.48 cm

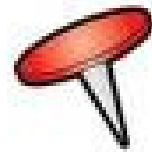
c. 1 yard (3 feet) = 0.91 m

d. 1 mile = 1.609 km d. 1 mile = 1.609 km

e. 1 pound = 0.45 kg

f. 1 gallon = 4.5 l

1 gram (g)



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4 quarts = 1 gallon

