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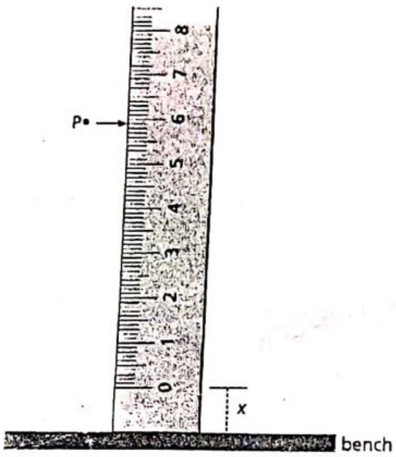
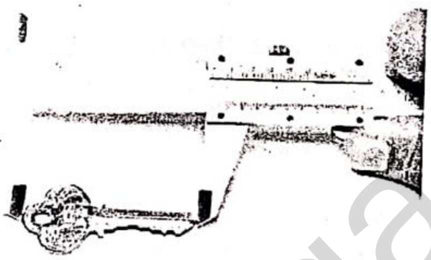
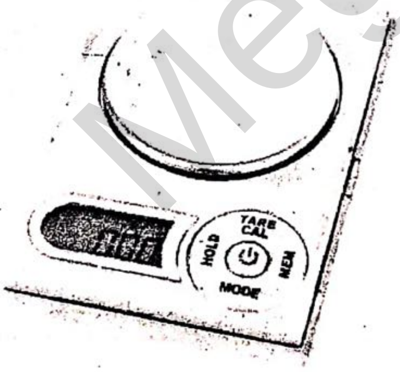
O Level Physics Syllabus Content for CAIE 2018-19 Exams

CHAPTER 1:
PHYSICAL QUANTITIES, UNITS AND MEASUREMENT







Syllabus Content

1.1 Scalars and vectors
1.2 Measurement techniques
1.3 Units and symbols

Learning outcomes

Candidates should be able to:

a) Define the terms *scalar* and *vector*.
b) Determine the resultant of two vectors by a graphical method.
c) List the vectors and scalars from distance, displacement, length, speed, velocity, time, acceleration, mass and force.
d) Describe how to measure a variety of lengths with appropriate accuracy using tapes, rules, micrometers and calipers. (The use of a vernier scale is **not** required.)
e) Describe how to measure a variety of time intervals using clocks and stopwatches.
f) Recognise and use the conventions and symbols contained in 'Signs, Symbols and Systematics',

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Physical Quantities, Units and Measurement

Basic Units:

In Physics, all physical quantities are usually measured in the "International System of Units", known as the SI units.

The "basic" quantities used in physics are:

1. Length: measures in meters (m).
2. Mass : measured in kilograms (kg).
3. Time : measured in seconds (s).

Some prefixes are used with the units to indicate a fraction of the unit or a multiple of the unit. Here are some important prefixes used in this course,

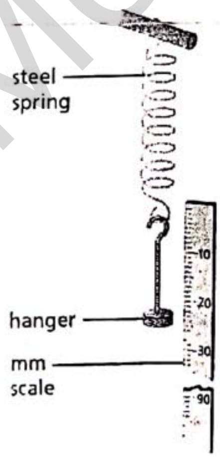
Prefixes	Notation	Prefixes	Notation
deci	(d) = 10^{-1}	kilo	(k) = 10^{3}
centi	(c) = 10^{-2}	micro	(μ) = 10^{-6}
mili	(m) = 10^{-3}	mega	(M) = 10^{6}

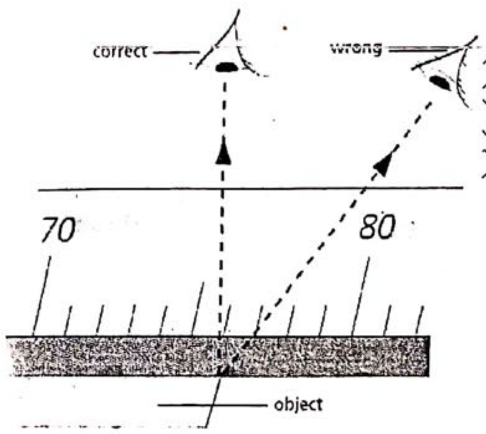
Measurements

For accuracy, a measurement is usually repeated several times, then the average value is obtained,

1. Measuring Lengths

A short distance or length is measured by a ruler, a longer distance is measured by a meter rule, very long distance (e.g. length of a hall or a game filed) are measured by using a long measuring tape or trundle wheel.





The correct way to measure with a ruler

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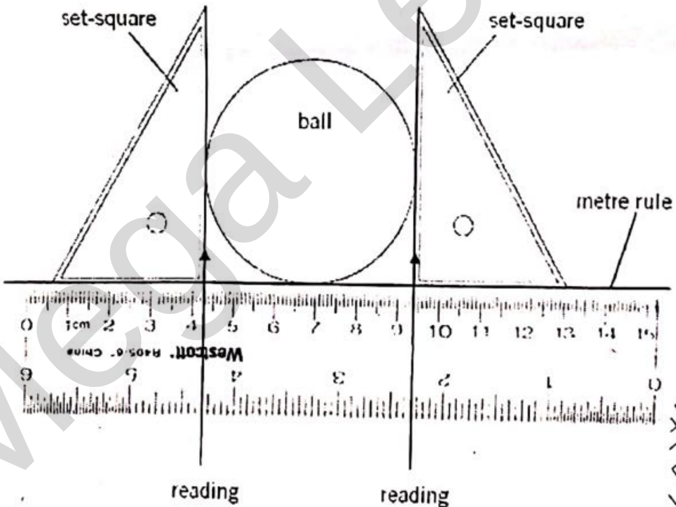
Steps:

1. Place the object very close to meter rule, (If you cannot do this, you may use a pointer).
2. Owing to the thickness of the ruler, the eye must be placed vertically above the mark being read to avoid the error due to parallax.
3. Take two readings at both ends of the object and subtract to the two readings to get the length.
4. Repeat the above steps several times and get the average value of the length.

Notes:

a. If a certain reading is found to be wrong, exclude it; or repeat the same measurement once again.
b. Many instruments which have a pointer moving above a scale are liable to parallax errors if the eye is not placed vertically above the pointer. Good instruments have a plane mirror under the scale. Parallax error is avoided if the eye is positioned so that the pointer exactly covers its own image in the mirror.
c. Parallax is the apparent relative motion of two objects owing to the movement of the observer.

Remarks:



1. When using a tape measure, avoid bends in the tape and keep it in a perpendicular direction to the two walls.
2. To measure the diameter of a sphere or a cylinder, place it between two vertical parallel blocks and take the difference between the two readings at its two ends.
3. If the system is not stable so you cannot place a ruler on it, one can use the dividers such that if two pins are exactly at the two ends of the distance to be measured, then place the dividers on a rule to find the required length.

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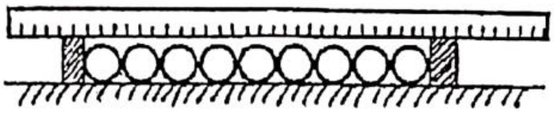
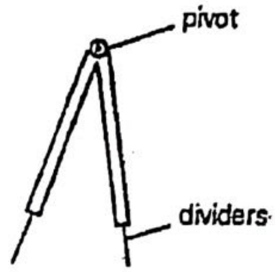
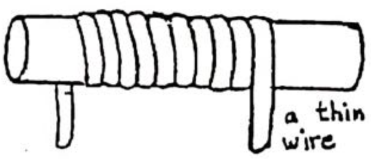




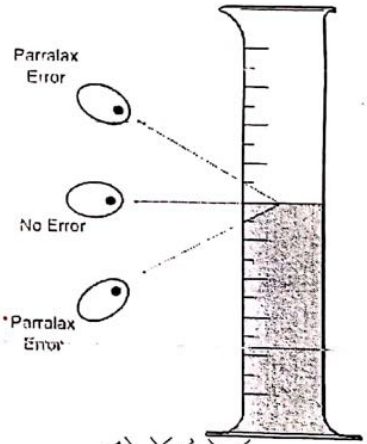


4. To measure the diameter of a wire, a bead, or a small ball bearing, one should arrange a row of a large number of them and measured the total length. Now, divide this length by the number of beads (to turns) to get the desired diameter.
5. Think how to get the thickness of a paper of your textbook.

2. Measuring Volumes:

(a) Volumes of Liquids:

The volume of a liquid is usually measured by a measuring cylinder. When measuring the volume by a cylinder, one should notice these precautions:



1. The Cylinder must be placed on a horizontal bench, otherwise error may arise due to titling.
2. Take the reading at the bottom of the meniscus or curved surface of the liquid. (mercury is an exceptional case, one reads at the top of the mercury's meniscus).
3. The line of eye sight should be perpendicular to the scale to avoid the error due to parallax.

(*) Small volume of liquids can be measured accurately by using a pipette or a burette.

(b) Volume of Regular solids:

The volume of a regular solid can be calculated by measuring dimensions and using the suitable formula.

For a rectangular block: Volume = length x width x height

For a sphere of radius "r": Volume = $\frac{4}{3}\pi r^3$

For cylinder of radius "r" & height "h" Volume =$2\pi r$ h

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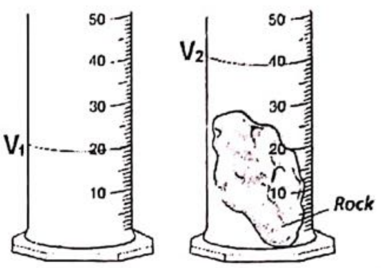
(c) Volume of Irregular solids:

The volume of solids of an irregular shape can be determined by immersing it in a liquid as follows:

1. Measure the volume (v_1) of a certain amount of a liquid by a measuring cylinder.
2. Tie the solids body by a fine thread and immerse it gently in the liquid, then get another reading for the volume (v_2) of the liquid plus the solids body.
3. The volume of the solids body equals (v_2-v_1)



Remarks:

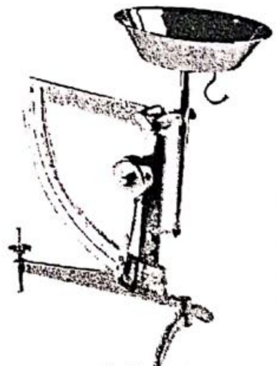
i. When measuring the volume of small particles containing air spaces (e.g. some particles), the measured volume is greater than the true volume of the particles only.

ii. Sometimes the displacement can, together with a measuring cylinder, can be used to measure the volume of an irregular solid, as shown in the figure.

3. Measuring Masses:

The Mass of a body is the measure of amount of substance contained in that body. The mass depends on the number and the type of the atoms contained in the body. The mass is usually measured in kilograms (or grams) by using a balance. The mass of an object is always constant; it does not change by change in place, temperature, time, etc.......

Top Pan Balance



Lever Balance

Mass can be measured by using a top-pan balance or a lever balance. When using a balance, notice that:

a. The balance is clean & dry,
b. The balance is placed horizontally,
c. The balance pointer or digits read zero (otherwise notice and record the zero error).

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Remarks:

When measuring very small object, measure several units and then divide by the number measured. In this way the error is divided by the number measured, thus error is reduced.

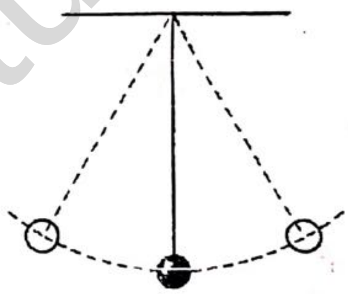
Example: To find the mass of a small pin, measure the mass of say, 50 pins using a balance, then divide the total mass by 50 to get the average mass of one pine.

4. Measuring Time:

1. Long periods of time are measured by a clock or watch.
2. Short times are measured by a stop-watch. (Make sure to reset the stop-watch to zero before starting a measurement).
3. Very short times (fraction of seconds) are measured by electronics timers which should start and stop automatically.

Experiment:

Measuring the periodic time of a Pendulum:



Apparatus: a stand & clamps, a pendulum bob, a meter rule and a stopwatch.

Steps:

1. Measure the length of Pendulum (from the hanging Point to the center of mass of bob).
2. Set the pendulum to swing, (a complete swing, or oscillation, starts from one end, all the way to the other end and coming back).
3. When the bob is at one end, start you stop-watch and count 30 complete swings then stop you stop-watch, and record the time taken by these swings.
4. Repeat above steps for different length of pendulum (use about 80, 60, & 40 cm).
5. Tabulate your results and find the time taken by one swing for each length.

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Table of Results:

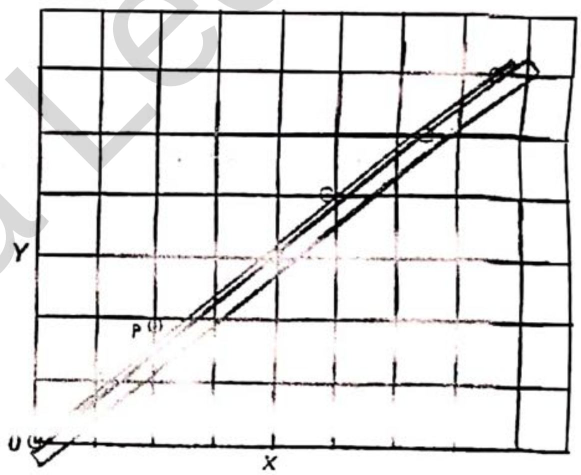
Length of Pendulum L/ cm	Time of 30 Swings t/s	Time of one swing, T/S (T =t/30)

All measurement should be carefully recorded in a "Table of Results". It should contain headings for all quantities measured together with the units used.

1. The table of results of the simple pendulum experiment which has been given before is a good example.
2. When measuring the time taken by a free falling body, one can use an electronic timer to get an accurate value of this very small time. If the experiment is done by a stop-watch, one has to repeat each measu[illegible] calculate the average time of fall.

Distance d/cm	Time of fall t/s			Ave time of fall [illegible]
	t_1	t_2	t_3	

Graphs:

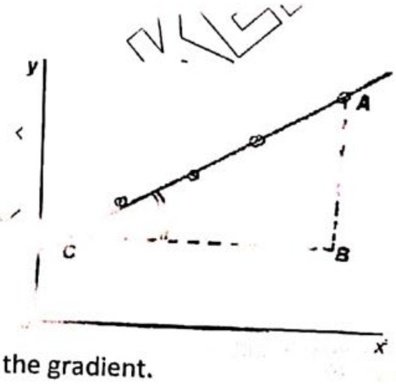


The graph should have:

a) A title
b) *Both axes labeled*
c) Units on each axis.
d) Scales used o[illegible] axis.
e) Poi[illegible]ted with crosses (x) or with dot [illegible]le (.)

The [illegible]r all graph paper.
[illegible]ght line (or smooth curve) which passes through most of the points (or leaves equ[illegible] no. of points on either side of gr[illegible]h).

Gradient or Slope:



T[illegible] gradient (or slope) of a line is the tangent of the [illegible]e θ [illegible]hich the line makes with the horizontal.

Gradie[illegible] tan θ = $\frac{AB}{BC}$

= $\frac{\text{[illegible]}}{\text{Horizontal}}$

- Write the units used for AB & BC to get the unit of the gradient.
- If the line slopes downwards to the right, the gradient is negative

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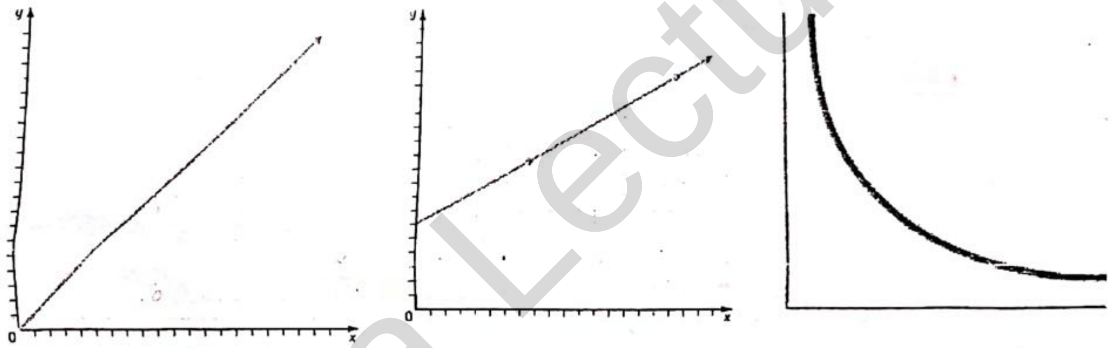
How to choose a convenient scale for an axis:

- **a)** suppose that the minimum number in the date is A and the maximum number is B,
- **b)** Count the number of scale divisions available for representing between A and B. Let this number be N.
- **c)** Calculate (B-A) /N. Find a number composed of either 1 or 2 or 5 that is just greater than B-A/N. This number will be the scale division.

Example:

Assume the largest number in the data is 12.3 and the smallest number is 5.8. Assume there are 17 divisions available for these date. (12.3- 5.8)/ 17=0.38. Then each scale division will be 0.5. The starting number in the axis is 5.5 and the last number is 12.5.

Proportionality:

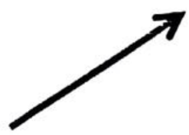


(a) (b) (c)

- **a)** The relation between two variables is directly proportional when relation is straight line through the origin Fig. (a). (y = k.x).
- **b)** The relation is linear but not directly proportional when relation is a straight line but not through the origin Fig. (b). y = k.x + c
- **c)** The inversely proportional relation gives a curve Fig. (c). (y.x =k).

Vectors and Scalars:

A vector quantity is that which has both magnitude and direction.



Examples: Displacement, Force, weight, velocity, acceleration, momentum...

A vector is usually represented by an arrow whose length is proportional to the size of the vector and it points in the direction of the vector. A good representation of the vector needs to choose a suitable scale for drawing the vector.

A Scalars quantity is that which has magnitude only.

It has NO direction.

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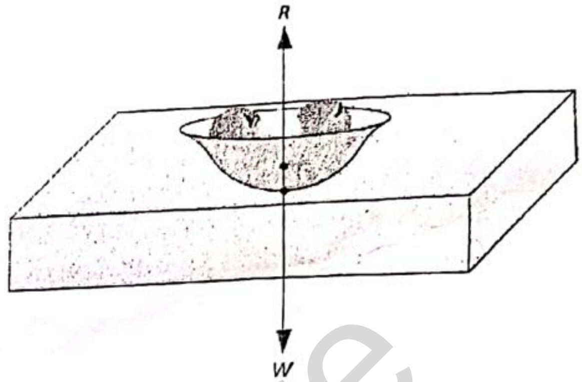
Examples: mass, length, volume, temperature, time, energy...

Forces and resultants

Force has both magnitude (size) and direction. It is represented in diagrams by a straight line with an arrow to show its direction of action. Usually more than one force acts on an object. As a simple example, an object resting on a table is pulled downwards by its weight *W* and pushed upwards by a force *R* due to the table supporting it (see Figure below). Since the object is at rest, the forces must balance, i.e. $R = W$.



In structures such as a giant oil platform, two or more forces may act at the same point. It is then often useful for the design engineer to know the value of the single force, i.e. the **resultant**, which has exactly the same effect as these forces. If the forces act in the same straight line, the resultant is found by simple addition or subtraction as shown in Figure; if they do not they are added by using the parallelogram law.

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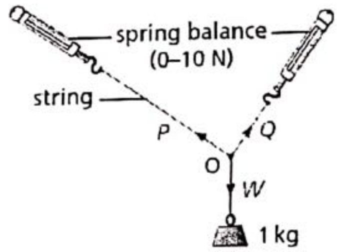
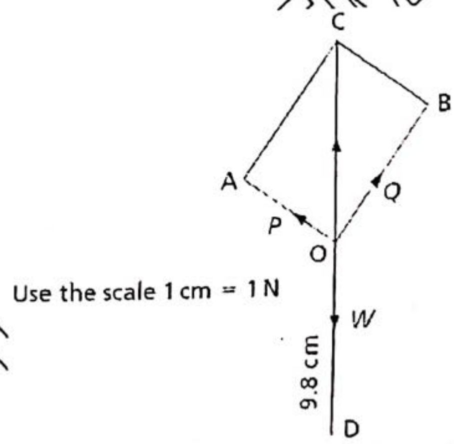
Parallelogram law

Arrange the apparatus as in Figure with a sheet of paper behind it on a vertical board. We have to find the resultant of forces *P* and *Q*. Read the values of *P* and *Q* from the spring balances. Mark on the paper the directions of *P*, *Q* and *W* as shown by the strings. Remove the paper and, using a scale of 1 cm to represent 1 N, draw OA, OB and OD to represent the three forces *P*, *Q* and *W* which act at O, as in Figure 7.4b. (*W* = weight of the 1 kg mass = 9.8 N; therefore OD = 9.8 cm.)



P and *Q* together are balanced by *W* and so their resultant must be a force equal and opposite to *W*. Complete the parallelogram OACB. Measure the diagonal OC; if it is equal in size (i.e. 9.8 cm) and opposite in direction to *W* then it represents the resultant of *P* and *Q*. The parallelogram law for adding two forces is: If two forces acting at a point are represented in size and direction by the sides of a parallelogram drawn from the point, their resultant is represented in size and direction by the diagonal of the parallelogram drawn from the point.



Finding a resultant by the parallelogram law

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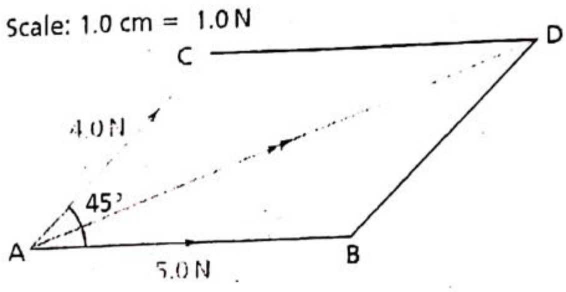
Worked example

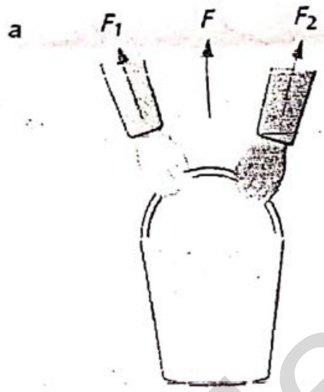
Find the resultant of two forces of 4.0 N and 5.0 N acting at an angle of 45. to each other. Using a scale of 1.0 cm = 1.0 N, draw parallelogram ABDC with AB = 5.0 cm, AC = 4.0 N and angle CAB = 45. By the parallelogram law, the diagonal AD represents the resultant in magnitude and direction; it measures 8.3 cm, and angle BAD = 20. ∴Resultant is a force of 8.3 N acting at an angle of 20. to the force of 5.0 N.

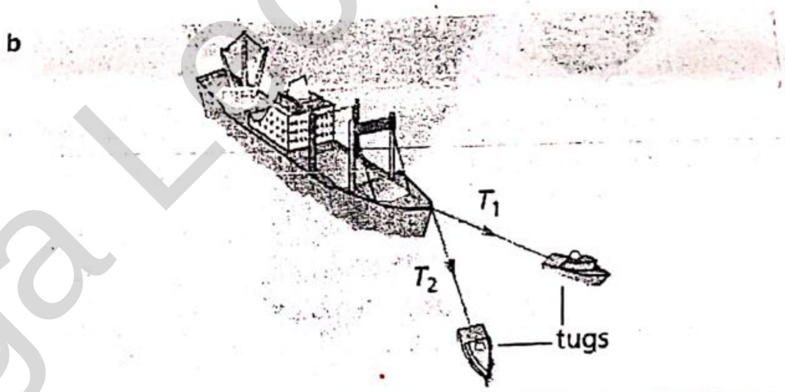


Examples of addition of forces

a) Two people carrying a heavy bucket. The weight of the bucket is balanced by the force *F*, the resultant of *F*1 and *F*2.

b) Two tugs pulling a ship. The resultant of *T*1 and *T*2 is forwards in direction, and so the ship moves forwards (as long as the resultant is greater than the resistance to motion of the sea and the wind).





Vectors and scalars

A **vector** quantity is one such as force which is described completely only if both its size (magnitude) and direction are stated. It is not enough to say, for example, a force of 10 N, but rather a force of 10 N acting vertically downwards. A vector can be represented by a straight line whose length represents the magnitude of the quantity and whose direction gives its line of action. An arrow on the line shows which way along the line it acts.

A **scalar** quantity has magnitude only. Mass is a scalar and is completely described when its value is known. Scalars are added by ordinary arithmetic; vectors are added geometrically, taking account of their directions as well as their magnitudes.

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