A Level Physics Knowledge Organiser

Foundations of physics

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1. Quantities and units

Physical quantity	A property of an object, substance or phenomenon that can be measured.
International System of Units (SI)	The International System of Units is the modern form of the metric system. It is the only system of measurement with an official status in nearly every country in the world.
Base unit	One of seven units that form the building blocks of the SI measurement system.

SI base units

Quantity	Base unit	Unit symbol
length	metre	m
mass	kilogram	kg
time	second	s
electric current	ampère	A
temperature	kelvin	K
amount of substance	mole	mol

Symbols	A unit symbol is written in lower case unless the unit is named after a person. (metre, m) In that situation, its name still begins with a lower-case letter but its symbol has a capital letter. (ampere, A)
Prefix	A word or letter placed before another one, for example, 5.0 km is 5.0 x 10^3 m.

Prefix name	Prefix symbol	Factor
peta	P	10^{15}
tera	T	10^{12}
giga	G	10^{9}
mega	M	10^{6}
kilo	k	10^{3}
deci	d	10^{-1}
centi	c	10^{-2}
milli	m	10^{-3}
micro	μ	10^{-6}
nano	n	10^{-9}
pico	p	10^{-12}
femto	f	10^{-15}

Standard form	Standard form is used to display very small or very large numbers in a scientific way. For scientific notation it is ideally expressed in the form $n \times 10^m$ where $1<n<10$, and m is an integer.

2. Derived units

Derived quantity	A quantity that comes from a combination of base units.
Derived unit	A unit used to represent a derived quantity, such as N for force.
Derived units without special names	- You can determine derived units from the equation for the derived quantity. - Average speed is a derived quantity. The equation is $\text{average speed} = \frac{\text{distance travelled}}{\text{time taken}}$ - The unit for distance is metre (m), second (s) is the unit for time, and we are dividing m by s, the derived unit for speed is m/s, written m s^{-1} at A level. (s^{-1} = 1/s) - We write derived units like this because it is better for more complex units. (J kg^{-1} K^{-1} is better than J/(kgK))

Some derived units without special names

Derived quantity	Derived unit
area	m^2
volume	m^3
acceleration	$m\,s^{-2}$
density	$kg\,m^{-3}$

Derived units with special names	SI has 22 derived units with special names and symbols.

Some named derived units

Derived quantity	Unit name	Unit symbol	Unit expressed in other SI units
force	newton	N	$kg\,m\,s^{-2}$
pressure	pascal	Pa	$N\,m^{-2}$
energy or work done	joule	J	N m
power	watt	W	$J\,s^{-1}$
electric potential difference	volt	V	$J\,C^{-1}$
electric resistance	ohm	Ω	$V\,A^{-1}$
electric charge	coulomb	C	A s
frequency	hertz	Hz	s^{-1}

3. Scalar and vector quantities

Scalar quantity	A quantity with magnitude (size) but no direction.

Some scalar quantities and units

Scalar quantity	SI unit
length	m
mass	kg
time	s
speed	$m\,s^{-1}$
temperature	K, °C
volume	m^3
energy	J
potential difference	V
power	W

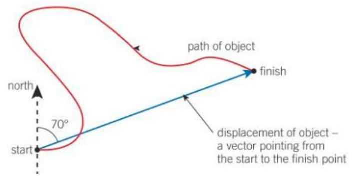
Adding and subtracting scalar quantities	- Scalar quantities can be added together or subtracted from one another in the usual way. - Scalar quantities must have the same units when you add or subtract them.
Multiplying and dividing scalar quantities	- Scalar quantities can be multiplied together or divided by one another. - The units can be the same or different.
Vector quantity	A quantity with magnitude (size) and direction.

Some vector quantities and units

Vector quantity	SI unit
displacement	m
velocity	$m\,s^{-1}$
acceleration	$m\,s^{-2}$
force	N ($kg\,m\,s^{-2}$)
momentum	$kg\,m\,s^{-1}$

Distance and displacement

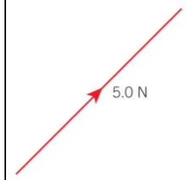
- Distance and displacement are both measured in metres (m).
- Distance is a scalar quantity.
- Displacement is a vector quantity.



4. Adding vectors

Resultant vector	A single vector that has the same effect as two or more vectors added together.

Vector representation



- The length of the line represents the magnitude of the vector, drawn to scale.
- The direction in which the arrowhead points represents the direction of the vector.

Parallel vectors	- Vectors in the same line and direction. - The direction of the resultant vector is the same as the individual vectors but its magnitude is greater.

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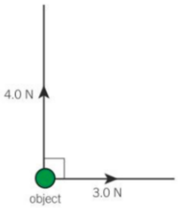
Antiparallel vectors

- Vectors in the same line but opposite directions.
- You call one direction positive and the opposite direction negative, it does not matter which.
- The magnitude and direction of the resultant will depend on the magnitude of the two vectors.

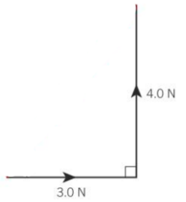
Two perpendicular vectors



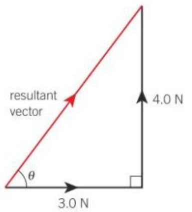
The resultant vector can be found either by calculation or by scale drawing of a vector triangle.

Vector triangle

- Draw a line to represent the first vector
- Draw a line to represent the second vector, starting from the end of the first vector.



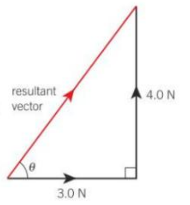
- To find the resultant vector, join the start to the finish. You have created a vector triangle.



- The angle between the vectors need not be 90°, any triangle works.

Pythagoras' theorem

The square of the length of the hypotenuse of a right-angled triangle equals the sum of the squares of the lengths of the other two sides.
For this example



$$F^2 = 4.0^2 + 3.0^2$$

$$F = \sqrt{4.0^2 + 3.0^2} = \sqrt{25}$$

$$F = 5.0\,\text{N}$$

To find the direction of the resultant force, you can calculate the angle θ as

$$\tan\theta = \frac{\text{opp}}{\text{adj}} = \frac{4.0}{3.0} = 1.333$$

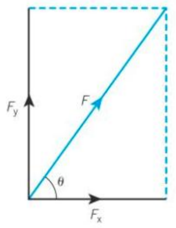
$$\theta = 53^\circ$$

5. Resolving vectors

Resolving a vector

Splitting a vector into two component vectors perpendicular to each other.
It can be done using a scale drawing or by calculation.

Resolving a vector into two components by scale drawing



Resolving a vector into two components by calculation

To resolve a force F into the x and y directions, the two components of the force are

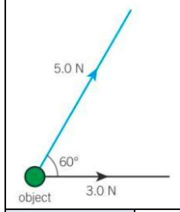
$F_x = F \cos\theta$

$F_y = F \sin\theta$

θ – angle made with the x direction

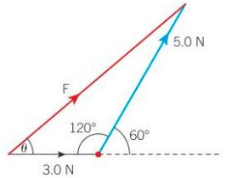
6. More on vectors

Adding non-perpendicular vectors



Scale diagram – vector triangle

Choose an appropriate scale for the drawing of your vector triangle.



Cosine and sine rules

Cosine rule

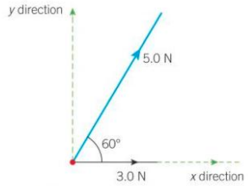
$a^2 = b^2 + c^2 - 2bc\cos\theta$

Sine rule

$$\frac{a}{\sin A} = \frac{b}{\sin B}$$

Vector resolution

- This technique relies on choosing convenient perpendicular axis.
For example



- One of the vectors is resolved along each axis so that the magnitude of the resultant vector can be determined using Pythagoras' theorem.

total force in x direction $= 3.0 + 5.0\cos 60^\circ = 5.5\,\text{N}$

total force in y direction $= 5.0\sin 60^\circ = 4.33\,\text{N}$

resultant force $F = \sqrt{5.5^2 + 4.33^2} = 7.0\,\text{N}$

$$\theta = \tan^{-1}\left(\frac{4.33}{5.5}\right) = 38^\circ$$

Subtracting vectors

- Two vectors are represented by X and Y.

- To subtract Y from X, you simply reverse the direction of Y and then add this new vector to X.