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Support Pack | Grade 12

CAPS

Physical Sciences

Physics information sheets

This support pack for the **Physics section** of the **Physical Sciences Grade 12 CAPS curriculum** provides revision of important basic information and concepts that learners need to know to successfully cope with Physics at Grade 12 level. Learners can work through these individually at home or these could form the basis of a catch-up class or online lesson. You have permission to print or photocopy this document or distribute it electronically via email or WhatsApp.

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SI units

In South Africa we use the International System of Units. This is abbreviated as SI (from the French name Système International d'Unitès). There are seven basic units and all other units are derived from these seven. They are:

- length (distance) in metres (m)
- time in seconds (s)
- mass in kilograms (kg)
- electric current in ampere (A)
- temperature in kelvin (K)
- luminous intensity in candela (cd)
- amount of substance in mole (mol).

A set of derived units is also used. Here is a list of some of these units that you will come across in this book:

Quantity	Symbol	SI unit
Position	x, y	metre (m)
Displacement	Δx, Δy or s	metre (m)
Acceleration	a	metre per second squared ($m \cdot s^{-2}$)
Initial velocity	v_i or u	metre per second ($m \cdot s^{-1}$)
Final velocity	v_f or v	metre per second ($m \cdot s^{-1}$)
Time (instant)	t	second (s)
Time interval	Δt	second (s)
Mass	m	kilogram (kg)
Weight	w	newton (N)
Gravitational acceleration	g	metre per second squared ($m \cdot s^{-2}$)
Force	F	newton (N)
Normal force	N	newton (N)
Tension	T	newton (N)
Friction force	f	newton (N)
Coefficient of friction	μ, μs, μd	no units
Potential energy	U or E_p	joule (J)
Kinetic energy	K or E_k	joule (J)
Momentum	p	kilogram metre per second ($kg \cdot m \cdot s^{-1}$)
Frequency	f	hertz (Hz)
Period	T	second (s)
Wave speed	v	metre per second ($m \cdot s^{-1}$)
Wavelength	λ	metre (m)
Voltage or potential difference	V	volt (V)
Work done	W	joule (J)
Emf	ε	volt (V)
Electric charge	Q, q	coulomb (C)
Electric current	I	ampere (A)
Resistance	R	ohm (Ω)
Internal resistance	r	ohm (Ω)
Magnetic field	B	tesla (T)
Magnetic flux	Φ	weber (Wb)
Work function of a metal	W_0	joule (J)
Energy transferred	E	joule (J)
Power	P	watt (W)

Other units that are sometimes used:

Quantity	Symbol	Other units
Displacement	Δx	kilometre (km); mile
Time	t	minute (min); hour (h)
Velocity	v	kilometres per hour ($km{\cdot}h^{-1}$); miles per hour (mph)

Indicating units

There are a number of ways to indicate units: metres per second is the unit of speed. This unit means that you divide the distance in metres by the time in seconds. According to the SI system, this unit can be written as m/s, $m\ s^{-1}$ or $m{\cdot}s^{-1}$.

SI prefixes

To convert in the decimal system, you need to know the metric multiples:

Prefix	Abbreviation	Factor
tera-	T	10^{12}
giga-	G	10^{9}
mega-	M	10^{6}
kilo-	k	10^{3} = 1 000
hecto-	h	10^{2} = 100
deca-	da	10^{1} = 10
deci-	d	10^{-1} = 0,1
centi-	c	10^{-2} = 0,01
milli-	m	10^{-3} = 0,001
micro-	μ	10^{-6}
nano-	n	10^{-9}
pico-	p	10^{-12}

Converting units

Units must always be converted to SI units.

To convert 2 hours to minutes, multiply by 60, and then to get seconds, multiply by 60 again.

Example: 2 h × 60 = 120 min × 60 = 7 200 s

To convert from seconds to hours, divide by 3 600 (60 × 60).

To convert within the decimal system, multiply by the correct factor and use the correct prefix according to the list of metric multiples above.

Example:

	×10		×10		×10		×10		×10		×10	
	→		→		→		→		→		→	
km		hm		dam		m		dm		cm		mm
	←		←		←		←		←		←	
	÷10		÷10		÷10		÷10		÷10		÷10	

To convert from $km \cdot h^{-1}$ to $m \cdot s^{-1}$:

$$1 \frac{km}{h} = \frac{1\ 000\ m}{60 \times 60\ s} = \frac{1}{3{,}6} = 0{,}278\ m \cdot s^{-1} \quad \therefore \frac{km \cdot h^{-1}}{3{,}6} = m \cdot s^{-1}$$

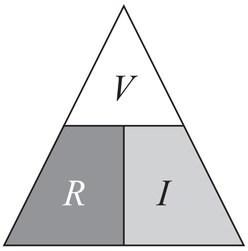
To convert from $m \cdot s^{-1}$ to $km \cdot h^{-1}$:

$$1 \frac{m}{s} = \frac{60 \times 60\ s}{1\ 000\ m} = 3{,}6\ km \cdot h^{-1} \qquad \therefore m \cdot s^{-1} \times 3{,}6 = km \cdot h^{-1}$$

Greek symbols

We sometimes use the letters from the Greek alphabet as symbols in science. In Grade 12 we will use the following symbols:

Greek letter	Greek name	Meaning in science	Example
α	Alpha	Subatomic particle	α-particle
β	Beta	Subatomic particle	β-particle
γ	Gamma	Subatomic particle	γ-particle
δ	Delta	Partially	δ^- partially negative
λ	Lambda	Wavelength	$\lambda = 5$ m
Δ	Delta (capital)	Change in	Δv change in velocity
σ	Sigma	Stress	$\sigma = \frac{\text{force}}{\text{area}}$
$\mathcal{E}$	Epsilon	Strain	$\mathcal{E} = \frac{\Delta L}{L}$
τ	Tau	Symbol for torque	$\tau = F' r$
Φ	Phi	Symbol for magnetic flux	$\Phi = B \times A$
Ω	Omega	Ohm	Unit of resistance: $R = 5\ \Omega$



Rearranging equations

When there are three quantities involved in an equation, it is often easier to use the equation triangle. In the triangle the horizontal line represents division, and the vertical line represents multiplication.

- Draw the triangle.
- Add the quantities in the correct positions.
- With your finger, cover the quantity that must be calculated to find out if the other two quantities need to be divided or multiplied.

The scientific method

The scientific method is used in all sciences as a systematic approach to research. There are five steps in the scientific method:

Step 1: Identify and state the problem.

Step 2: Do experiments; collect data; make careful observations.

Step 3: Analyse the data and propose a possible solution to the problem by formulating a hypothesis. The hypothesis attempts to explain the observations.

Step 4: Do more experiments to test the hypothesis. Make sure the conclusions are correct.

Step 5: Formulate the results as a conclusion. The conclusion can be in the form of a theory, a principle or a law.

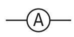
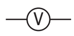
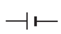
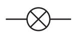
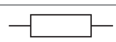
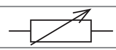
A **hypothesis** is a tentative explanation of the results of experiments or a set of observations.

A **theory** is a hypothesis that has withstood extensive testing.

A **law** is a verbal or mathematical description of behaviour based on the results of many experiments. Laws are consistent and have no known exceptions. Laws in this book include the Law of Conservation of Momentum and Hooke's Law.

A **model** is a real or mental picture that results from ideas and assumptions that are imagined to be true. It is used to explain certain observations and measurements. Models include the kinetic model of matter, the wave model of light and the atomic model.

Symbols used in circuit diagrams

Component	Symbol
Switch (open and closed)	
Ammeter	
Voltmeter	
Battery	 or 
Light bulb	
Resistor	
Rheostat	
Alternating current source	

Useful equations

Average velocity

$v = \frac{\Delta x}{\Delta t}$

Average acceleration

$a = \frac{\Delta v}{\Delta t}$

Equations of motion

$v_f = v_i + a\Delta t$	or	$v = u + a\Delta t$
$v_f^2 = v_i^2 + 2a\Delta x$	or	$v^2 = u^2 + 2a\Delta x$
$\Delta x = v_i\Delta t + \frac{1}{2}a\Delta t^2$	or	$\Delta x = u\Delta t + \frac{1}{2}a\Delta t^2$
$\Delta x = (\frac{v_i + v_f}{2})\Delta t$	or	$\Delta x = (\frac{u + v}{2})\Delta t$

Newton's Second Law

$F_{res} = ma$

Newton's Law of Universal Gravitation

$F = \frac{Gm_1m_2}{r^2}$

Weight

$w = mg$

Momentum

$p = mv$

Law of Conservation of Linear Momentum

momentum before collision = momentum after collision

$m_1v_{i\,1} + m_2v_{i\,2} = m_1v_{f\,1} + m_2v_{f\,2}$

Impulse

$F\Delta t = \Delta p$

Gravitational potential energy

$U = E_p = mgh$

Kinetic energy

$K = E_k = \frac{1}{2}mv^2$

Work done

$W = F{\cdot}\Delta x$ or $W = \Delta K$

Power

$P = \frac{W}{\Delta t}$ or $P = Fv$ (if an object travels at constant velocity)

Law of Conservation of Mechanical Energy in an isolated system

$(U + K)_A = (U + K)_B$ where A and B are two different points

Potential difference

$V = \frac{W}{Q}$

Current

$I = \frac{Q}{\Delta t}$

Ohm's Law

$R = \frac{V}{I}$

Emf

$\mathcal{E} = V_{\text{load}} + V_{\text{internal resistance}}$

$= I(R + r)$

Batteries

$Q = It$

$E = QV$

Alternating current

$I_{\text{rms}} = \frac{I_{\text{max}}}{\sqrt{2}}$ and $V_{\text{rms}} = \frac{V_{\text{max}}}{\sqrt{2}}$

$P_{\text{avg}} = V_{\text{rms}} I_{\text{rms}} = \frac{V^2_{\text{rms}}}{R} = I^2_{\text{rms}} R$

$P_{\text{avg}} = \frac{1}{2} P_{\text{max}} = \frac{1}{2} V_{\text{max}} I_{\text{max}} = V_{\text{rms}} I_{\text{rms}}$

$V_{\text{rms}} = \frac{1}{\sqrt{2}} V_{\text{max}}$ and $I_{\text{rms}} = \frac{1}{\sqrt{2}} I_{\text{max}}$

Waves, light and sound

$v = f\lambda$

$T = \frac{1}{f}$

$f_{\text{L}} = \frac{v - v_{\text{L}}}{v - v_{\text{S}}} f_{\text{S}}$

$\sin \theta = \frac{m\lambda}{a}$

$E = hf$

$hf = W_0 + \frac{1}{2} mv^2$

Moles, mass and molar mass

$n = \frac{m}{M}$ $m = nM$ $M = \frac{m}{n}$

Concentration

$c = \frac{n}{V}$ $n = cV$ $V = \frac{n}{c}$

$c = \frac{m}{MV}$ $m = cVM$