Senpai's Last Minute Desperate Notes (Totally Not Copyrighted)

1 Physical quantities and units

1.1 Physical quantities

Candidates should be able to:

1 understand that all physical quantities consist of a numerical magnitude and a unit

2 make reasonable estimates of physical quantities included within the syllabus

- **Physical quantities** consist of a **numerical magnitude** and a **unit**
- Eg. When you are driving, the speedometer shows the speed as 120 km/h. The physical unit here is **speed**, with **120** being the **numerical magnitude** and **km/h** being the **unit**.

1.2 SI units

Candidates should be able to:

1 recall the following SI base quantities and their units: mass (kg), length (m), time (s), current (A), temperature (K)

2 express derived units as products or quotients of the SI base units and use the derived units for quantities listed in this syllabus as appropriate

3 use SI base units to check the homogeneity of physical equations

4 recall and use the following prefixes and their symbols to indicate decimal submultiples or multiples of both base and derived units: pico (p), nano (n), micro (μ), milli (m), centi (c), deci (d), kilo (k), mega (M), giga (G), tera (T)

- Note that the units used in the example above is not in **SI**. If we were to convert both the magnitude and units to SI, the speed would then be 33.3 m/s.
- SI unit is a system of measurement that is used and recognized in most countries (except US…)
- SI units can be categorized into two types; **based** and **derived**.
- There are seven base units:

QUANTITY	SI BASE UNIT	SYMBOL
MASS	KILOGRAM	kg
LENGTH	METRE	m
TIME	SECOND	s
CURRENT	AMPERE	A
TEMPERATURE	KELVIN	K
AMOUNT OF SUBSTANCE	MOLE	mol

- Derived units are derived from the seven based units (think of base units as Lego[TM] blocks and derived units as the castle/ ship/ car/ phone holder you are trying to make)
- Using the eg. above again, **m/s** is a derived SI unit since it is derived from both the base unit for **length** (or distance) (metre) and **time** (seconds).
- Speed is defined by the equation:
  speed = distance ÷ time
  speed = metres ÷ seconds
  Therefore, the SI units for Speed is metres / second (ms^{-1})
- You can use SI base units to check for the homogeneity of an equation.
- What this means is that for an equation, the units on the "left side" of an equal sign must be the same as the units on the "right side"
- Eg. from the kinematics equation v = u + gt
  v = m/s
  u = m/s
  g = m/s^2
  t = s

  "left hand side" = v = ms^{-1}
  "right hand side" = u + gt = $ms^{-1} + ms^{-2} x\ s = ms^{-1}$
  Since "left hand side" = "right hand side" the equation in homogenous

- Some important prefixes can be used to shorten large numbers or units for
- Eg. 100000 metres can be simplified with the prefix **kilo-** to 100 **kilometres (100 km)**
- Some important prefixes are shown below:

PREFIX	ABBREVIATION	POWER OF TEN
TERA–	T	10^{12}
GIGA–	G	10^{9}
MEGA–	M	10^{6}
KILO–	k	10^{3}
CENTI–	c	10^{-2}
MILLI–	m	10^{-3}
MICRO–	μ	10^{-6}
NANO–	n	10^{-9}
PICO–	p	10^{-12}

1.3 Errors and uncertainties

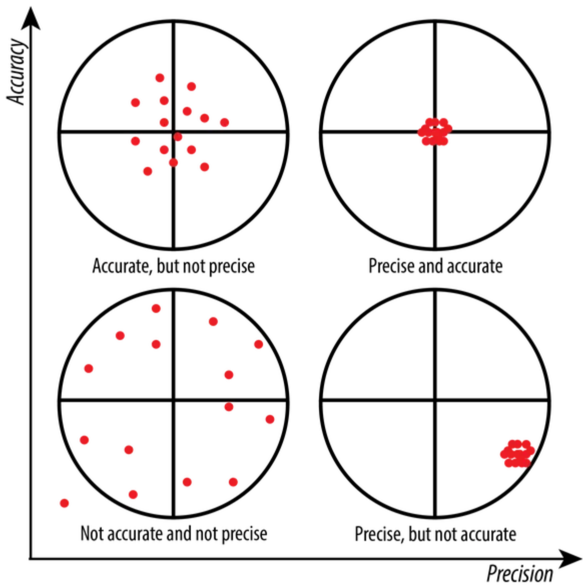
Candidates should be able to:

1 understand and explain the effects of systematic errors (including zero errors) and random errors in measurements

2 understand the distinction between precision and accuracy

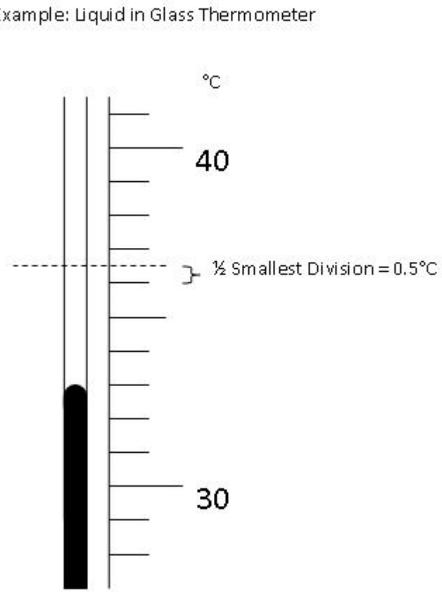
3 assess the uncertainty in a derived quantity by simple addition of absolute or percentage uncertainties

- When measuring anything, it is usually difficult to get accurate results due to there always being a degree of **uncertainty**.
- The cause for this uncertainty is **errors**.
- The two types of common errors are
  1) Random errors: Cause by fluctuations in an instrument due to unknown and unpredictable changes in an experiment.
     Eg. electrical noise in the circuit, heat loss due in a solar collector due to wind
  2) Systematic errors: From faulty instruments or from wrong techniques used in measurement.
     Eg. when using a weighing scale that doesn't show 0 grams before anything is placed on top.
- An instrument is said to be **accurate** if the values measured is close to the true value.
- An instrument is said to be **precise** if the values measured are close to each other when taking repeated measurements.
- An illustration showing accuracy and precision is shown below:



- **Uncertainty** is the difference between an actual reading and the true value.

- Uncertainty is a range of values around a measurement within which the true value is expected to lie.
- E.g. the true value of the mass of a bottle is 100 g. But when measured on a weighing scale, the reading gives 105 g, the uncertainty can therefore be read as ± 5 g
- To find uncertainties in different situations:
  Uncertainty in a reading: ± half the smallest division
  Uncertainty in a measurement: at least ±1 smallest division
  Uncertainty in repeated data: half the range i.e. ± $\frac{1}{2}$ (largest – smallest value)
  Uncertainty in digital readings: ± the last significant digit unless otherwise quoted
- These uncertainties can be represented in a number of ways:
  Absolute Uncertainty: where uncertainty is given as a fixed quantity
  Fractional Uncertainty: where uncertainty is given as a fraction of the measurement
  Percentage Uncertainty: where uncertainty is given as a percentage of the measurement
- E.g.



  The **absolute uncertainty** would be 0.5 x 1 ^{O}C = 0.5 ^{O}C
  T = 33 ± 0.5 ^{O}C
  The **fractional uncertainty** would be 0.5/33 = 1/66 ^{O}C
  T = 33 ± 1/66 ^{O}C
  The **percentage uncertainty** would be 1/66 x 100% = 1.5% ^{O}C
  T = 33 ± 1.5% ^{O}C
- Uncertainties can be combined following several rules:
- When adding / subtracting data – **add** the **absolute uncertainties**
- When multiplying / dividing data – **add** the **percentage uncertainties**
- When raising to a power – **multiply** the **fractional uncertainty** by the **power**

Combining Uncertainties

Adding or subtracting?

Add the absolute uncertainties

e.g. 1 +/- 0.1 V add to 2 +/- 0.2 V will give you 3 +/- 0.3 V

Multiplying or dividing?

Add the percentage uncertainties

e.g. 1 +/- 0.1 V multiply with 4 +/- 0.1 Amps

percentage uncertainty = 0.1/1x100 + 0.1/4x100 = 12.5%

Raising to a power?

Multiply the fractional uncertainty with the power

e.g. Length of a cube is 4.0 +/- 0.1 m its volume is then 4^3 +/- 3(0.1/4) = 64 +/-

1.4 Scalars and vectors

Candidates should be able to:

1 understand the difference between scalar and vector quantities and give examples of scalar and vector quantities included in the syllabus

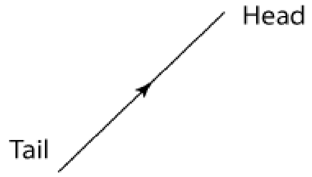
2 add and subtract coplanar vectors

3 represent a vector as two perpendicular components

- A **scalar** is a quantity which only has a **magnitude**
- E.g. speed, mass, time and distance
- A **vector** is a quantity with both a **magnitude** and **direction**
- Eg. velocity, acceleration, weight, and displacement
- If you want to know if a unit is a scalar or vector try putting a negative in front of it!
- E.g. for e.g. you cannot put a minus sign in front of mass because there is no negative mass! (yet)
- In A-levels, you need to know how to combine vectors. You probably already learned this in add maths or SPM physics.

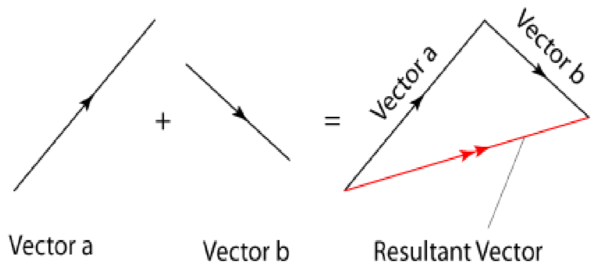
- Here's a refresher:

  Adding vectors

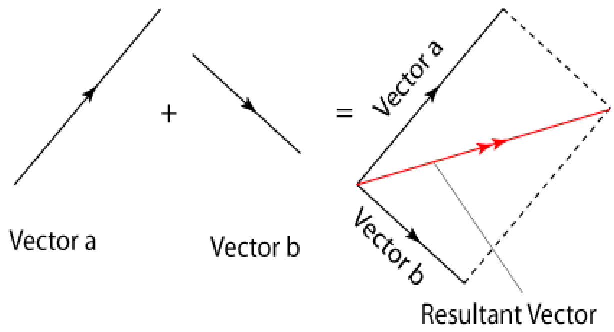


Vector Diagram

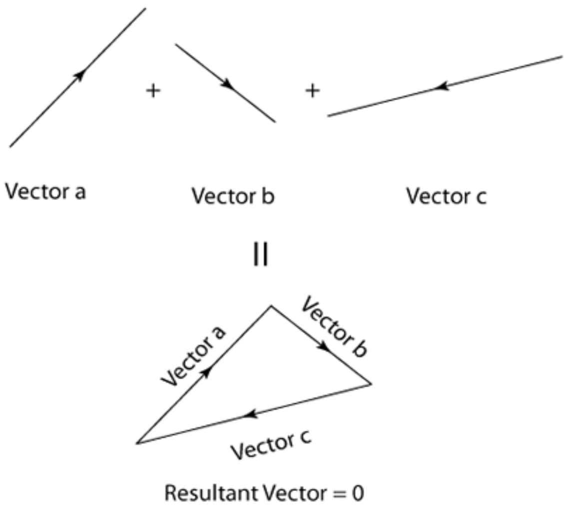
Triangle Method



Parallelogram Method



Vectors in equilibrium



<u>Resolving vectors in vertical and horizontal components</u>