Basics and Kinematics

Physics AS1

Base Quantities and Units

In Physics we use many quantities such as length, energy, time, speed.

Each quantity has its corresponding (SI) units (m,J,s,m/s).

Some quantities are fundamental and can be used to derive all other quantities. We call them base quantities.

The rest can be derived from the base quantities and we call them derived quantities.

Base Quantities and Units

- **Length** (unit: *metre* m),(symbol: L)
- **Mass** (unit: *kilogram* kg),(symbol: M)
- **Time** (unit: *second* s),(symbol: T)
- **Temperature** (unit: degree *Kelvin* K),(symbol: K)
- **Amount of Substance** – (unit: *mole* mol),(symbol: n)
- **Electric Current** (unit: *Ampere* A),(symbol: I)

Derived Quantities and Units

All other quantities (other than the base quantities) can be expressed by a formula involving base quantities.

energy = mass x length^2 x time^{-2} (ML^2T^{-2})

and its unit (the Joule) is J = kg . m^2.s^{-2}

some derived quantities do not have their own dedicated unit:

speed = length / time

and its unit is m/s (does not have own symbol)

We use base quantities and/or units to check the homogeneity of physical formulae - check both sides have the same units

Is $E = mc^2$ a homogeneously correct formula ?

Is $m.g.h$ a possible formula for energy ?

Is $p.V$ a possible formula for energy?

Warning*: a formula can be physically homogeneous and still be incorrect, for example mv^2 is homogeneous as energy but incorrect*

Numbers

In Physics numbers can be very large, eg 1430000000, or very small, eg 0.00000000012.

So we use exponential notation

We write 1430000000 as 1.43×10^9

and we write 0.00000000012 as 1.2×10^{-10}

practise some conversions …

Or we use prefixes

Prefixes are symbols which indicate specific multiples of units

When something is large...

Kilo : (symbol: k) x 1000 or 10^3
Mega : (symbol: M) x 1000000 or 10^6
Giga : (symbol: G) x 1000000000 or10^9
Tera : (symbol: T) x 1000000000000 or 10^{12}

What does 3.2 km mean?

What does 30 GW mean?

When something is small...

milli : (symbol: m) x 0.001 or 10^{-3}
micro : (symbol: μ) x 0.000001 or 10^{-6}
nano : (symbol: n) x 0.000000001 or 10^{-9}
pico : (symbol: p) x 0.000000000000 or 10^{-12}

A grain of rice has mass 12 mg.

A digital watch draws a current of 40 μA from its battery

A laser pen emits red light of wavelength 630 nm

Significant Digits

Numbers are usually given to a specific precision. The precision is related to the significant digits of the numerical description (of a quantity)

For example 3.14 is to three significant digits

13001 is to five significant digits but 13000 could be to 2,3,4 or 5 sig digs

Because 13000 has uncertain precision we prefer to use standard form. If we want to write 13000 to 2 sig digs we write 1.3×10^4 . If we want to write 13000 to five sig digs we write 1.3000×10^4

Examples …..

Calculations and precision

When you **add** or **subtract** quantities, do not increase the precision by adding digits in decimal places where one of the two quantities does not have significant digits.

Example: 75 + 0.33 = 75, but 74.983 + 0.33 = 75.31

Also 75+2x0.33=76

When you **multiply** or **divide** numbers, give your answer in the significant digits of the least precise. Example 4.56 x 13.8973 = 63.371688 = **63.4**

Example : area of a rectangle 2.1 x 4.3 = 9.0 (not 9.03) *explain why…..*

Exceptions (when using constants)

If there are **constants** in the calculations use the significant digits of the variables when giving the result of a calculation

If radius r=1.32 then diameter : 2r = 2x1.32 = 2.64

1.56 minutes is 1.56 x 60 = 93.6 seconds (not 94)

Understanding the difference between accuracy and precision

Accuracy describes the correctness of a value (how close it is to the true value)

Precision describes the level of detail in a value

Assuming that g=9.81 m/s^2, 9.236 m/s^2 is a **precise** value for g but **not accurate**. 10 m/s^2 is more accurate but less precise than 9.236 m/s^2

Note that accuracy is more important than precision

Motion in a straight line

We will learn two types of motion;

1. Motion with uniform (constant) velocity
2. Motion with uniform acceleration

(these two types of motion are idealized and don't cover all types: for example when your car accelerates it does so with a non-uniform acceleration)

you should learn the symbols that are used in motion

$$v, t, s, a, u$$

1. Motion with uniform (constant) velocity

here we have just one formula

$$v = \frac{s}{t}$$

2. Motion with uniform (constant) acceleration

here we have a few formulas

$$a = \frac{v - u}{t}$$

from which you can derive $v = u + at$

$$s = ut + \frac{1}{2}at^2$$

if you combine these two you get $v^2 = u^2 + 2as$

2. Motion with uniform (constant) acceleration

if you have **deceleration** instead of acceleration

$$a = \frac{u - v}{t}$$

from which you can derive $v = u - at$

$$s = ut - \frac{1}{2}at^2$$

if you combine these two you get $v^2 = u^2 - 2as$

2. Motion with uniform (constant) acceleration

we can generalise the previous two sets of formulas

$$a = \frac{v - u}{t} \qquad a = \frac{u - v}{t}$$

$$v = u \pm at$$

$$s = ut \pm \frac{1}{2}at^2$$

$$v^2 = u^2 \pm 2as$$

2. Motion with uniform (constant) acceleration

the simplest example of motion with uniform acceleration is motion under gravity. So expect many questions of objects moving in the air

in A-level Physics we use g, the acceleration of gravity, as $9.81 m/s^2$

when solving kinematics problems get your signs right

this is not always easy so …practise!

A stone is thrown vertically **upwards** with velocity 15 m/s from a balcony which is 10 m above ground. For the stone, find:

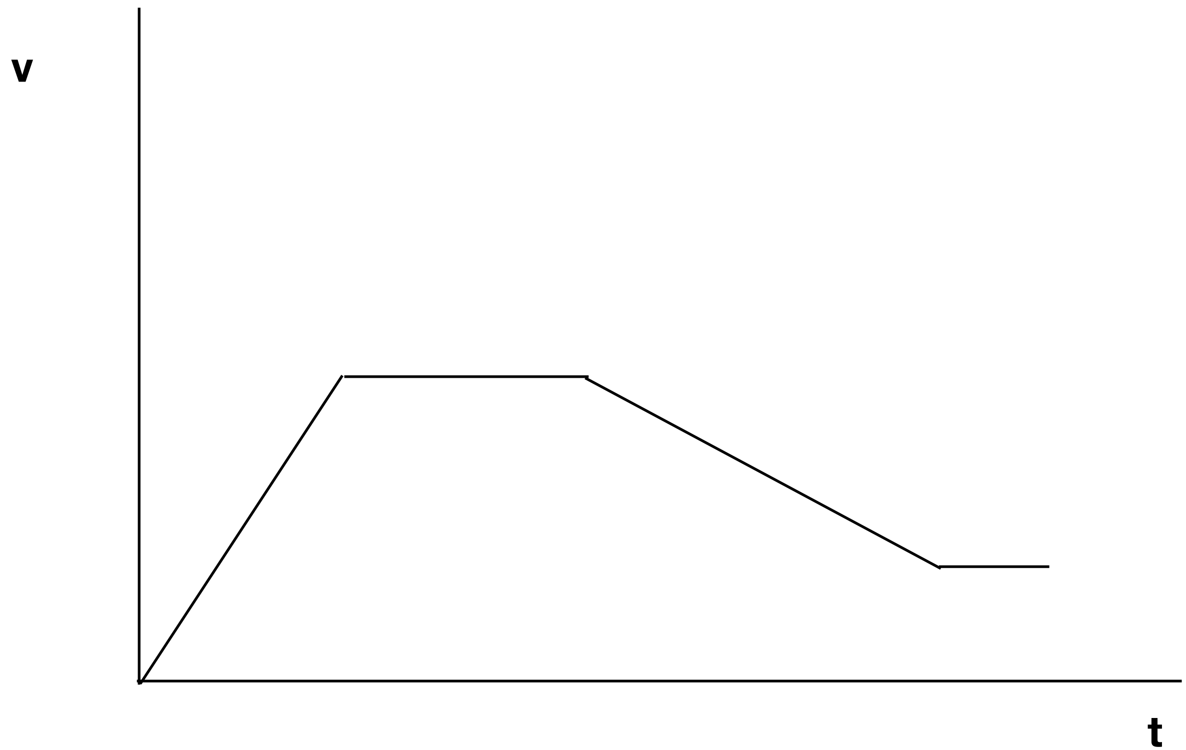
- Its velocity 1 s after it is thrown
- The maximum height reached and the time this is reached
- Its velocity when it reaches the level of the balcony
- Its velocity when it reaches the ground
- The time it takes to hit the ground

Kinematics graphs

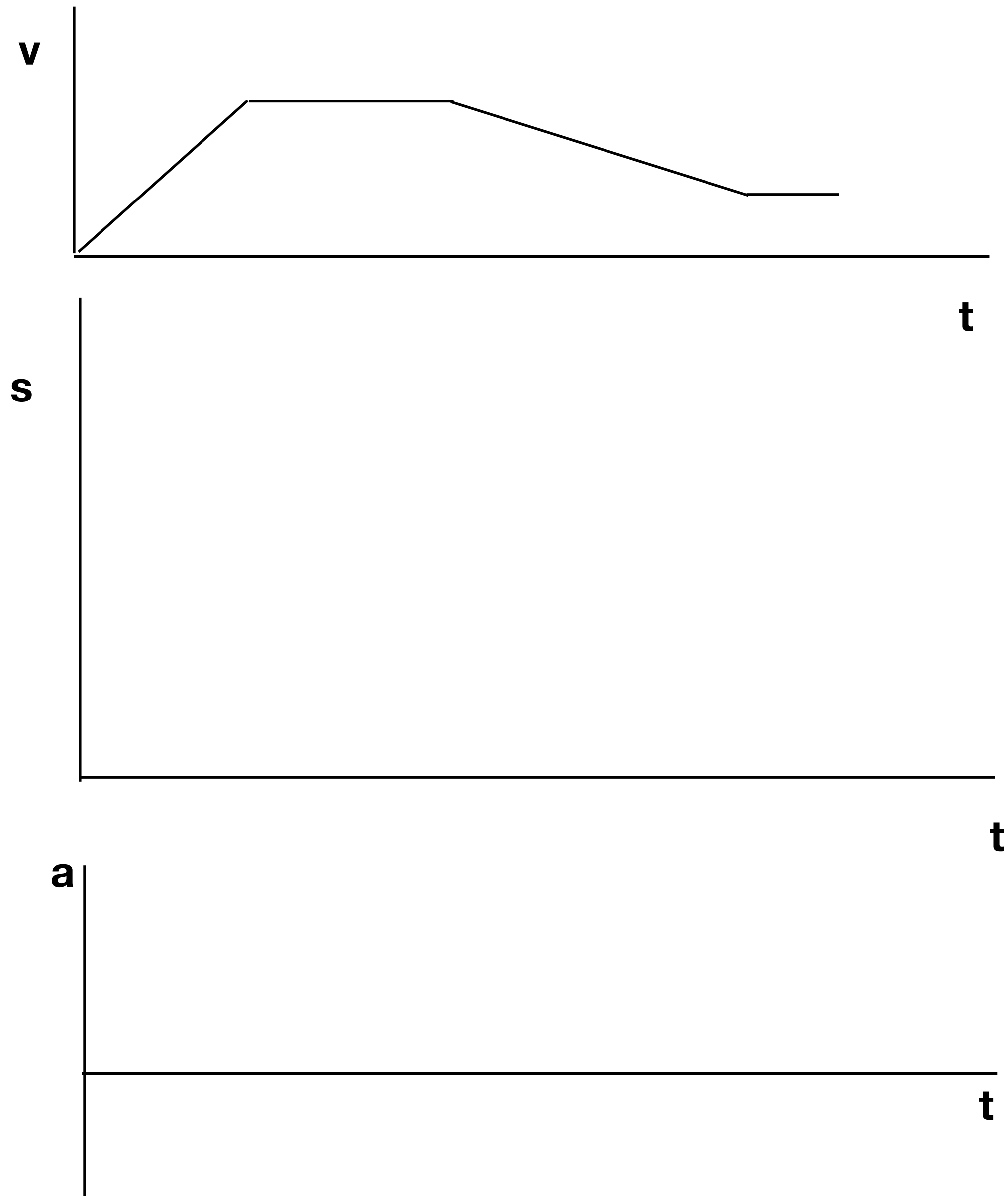
In physics we like graphs because they help us understand situations

The preferred graph in kinematics is the velocity versus time because it can also show the acceleration and the displacement

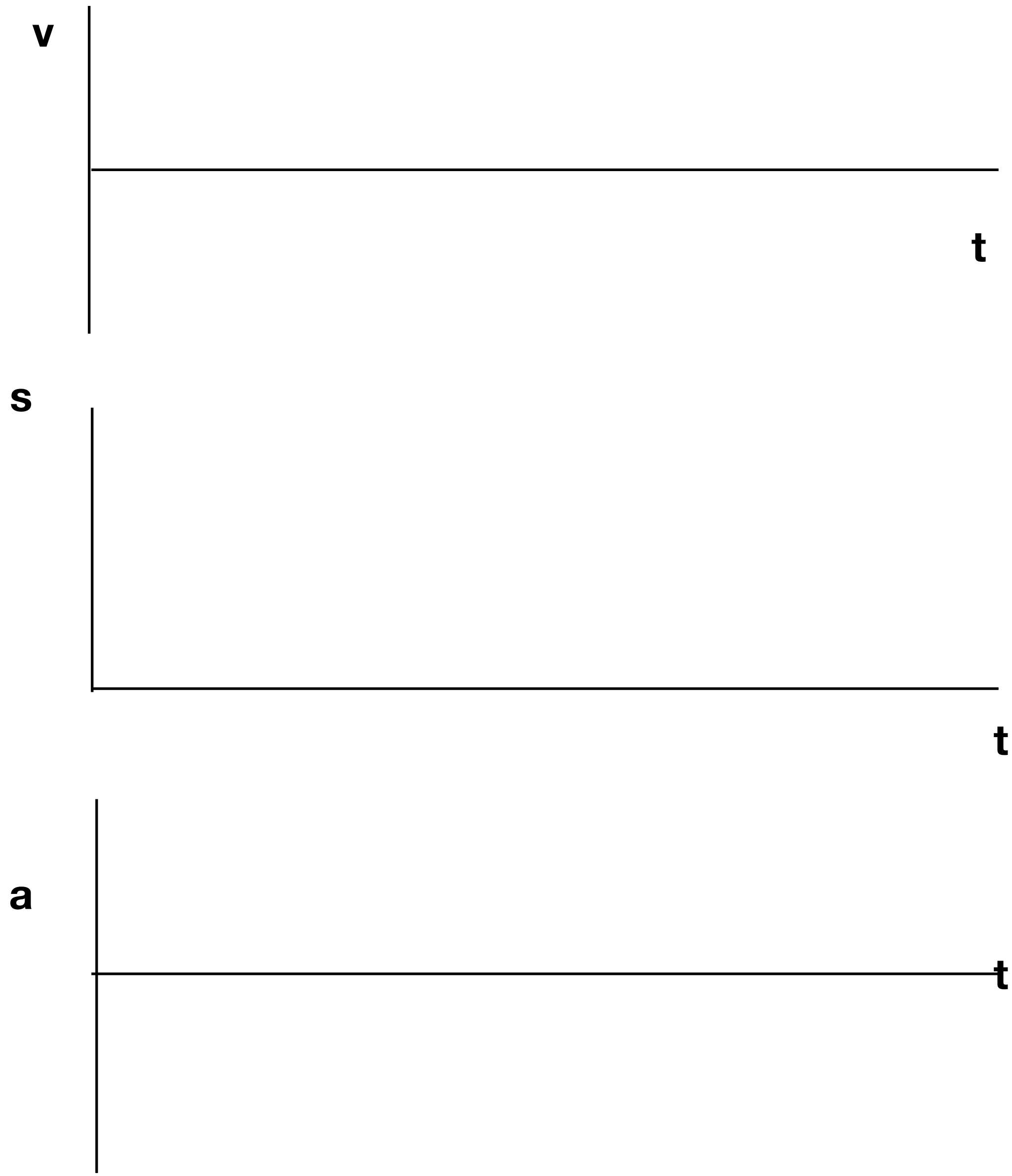
features of velocity graph



motion graphs



motion of bouncing ball



calculator

In physics you need a calculator to work answers out. You are allowed to use a calculator in the exams. Not any calculator but almost all the cost less than 50 euro are allowed

Casio scientific calculators are good value for money. For example FX-570EX, FX-350ES, FX-85GT or FX-991ES etc are good enough. These cost about 20-25 euro on the internet.

Some Casio calculators have been replicated in China and they cost less than 10 euro on Temu. They function just as well as the genuine Casio but if you click the buttons quickly they may miss a digit so, unless you are a slow user, you should avoid them