Year 12 Physics 2025-26

**INDUCTION WORK**



**XKCD**

Student

Class 12 A / B / C / D / E Form

**DYP 2024**

1. Physical Quantities

Maths and Physics have an important but overlooked distinction by students. Numbers in Physics have meaning – they are the size of physical quantities which exist. To give numbers meaning we suffix them with units. There are two types of units:

|  |  |
| --- | --- |
| **Basic quantity** | **Unit** |
| **Name** | **Symbol** |
| Mass | kilogram | kg  |
| Length | metre | m  |
| Time | second | s |
| Current | ampere | A  |
| Temperature | kelvin | K |
| Amount of substance | mole | mol |
| Luminous intensity | candela | cd |

**Base units** These are the seven fundamental quantities defined by the Système international d’Unités (SI units). Once defined, we can make measurements using the correct unit and make comparisons between values.

|  |  |
| --- | --- |
| **Derived quantity** | **Unit** |
| **Name** | **Symbols** |
| Volume | cubic metre | m3 |
| Velocity | metre per second | ms-1 |
| Density | kilogram per cubic metre | kgm-3 |

**Derived units** These are obtained by multiplying or dividing base units. Some derived units are complicated and are given simpler names, such as the unit of power Watt (W) which in SI units would be m2kgs-3.

|  |  |  |  |
| --- | --- | --- | --- |
| **Quantity** | **Quantity symbol** | **Unit name** | **Unit symbols** |
| Length | L or l or h or d or s | metre | m |
| Wavelength | λ | metre | m |
| Mass | m or M | kilogram | kg |
| Time | t | second | s |
| Temperature | T | kelvin | K |
| Charge | Q | coulomb | C |
| Momentum | p | kilogram metres per second | kg ms-1 |

**Notice that at A-Level we use the equivalent notation ms-1 rather than m/s.**

Do not become confused between the symbol we give to the quantity itself, and the symbol we give to the unit. For some examples, see the table on the right.

|  |  |  |  |
| --- | --- | --- | --- |
| **Prefix** | **Symbol** | **Name** | **Multiplier** |
| femto | f | quadrillionth | 10-15 |
| pico | p | trillionth | 10-12 |
| nano | n | billionth | 10-9 |
| micro | µ | millionth | 10-6 |
| milli | m | thousandth | 10-3 |
| centi | c | hundredth | 10-2 |
| kilo | k | thousand | 103 |
| mega | M | million | 106 |
| giga | G | billion | 109 |
| tera | T | trillion | 1012 |
| peta | P | quadrillion | 1015 |

Often the value of the quantity we are interested in is very big or small. To save space and simplify these numbers, we prefix the units with a set of symbols.

**Knowledge of standard form and how to input it into your calculator is essential.**

*For example:* 245 x 10-12 m = 245 pm

 2.45 x 103 m = 2.45 km

We may need to convert units to make comparisons.

*For example:* Which is bigger, 0.167 GW or 1500 MW?

 0.167 GW = 0.167 x109 W

 = 167 x106 W

 = 167 MW < 1500 MW

Physical Quantities - Questions

1. The unit of energy is the joule. Find out what this unit is expressed in terms of the base SI units.
2. Convert these numbers into normal form:
	1. 5.239 x 103
	2. 4.543 x 104
	3. 9.382 x 102
	4. 6.665 x 10-6
	5. 1.951 x 10-2
	6. 1.905 x 105
	7. 6.005 x 103
3. Convert these quantities into standard form:
	1. 65345 N
	2. 765 s
	3. 486856 W
	4. 0.987 cm2
	5. 0.000567 F
	6. 0.0000605 C
	7. 0.03000045 J
4. Write down the solutions to these problems, giving your answer in standard form:
	1. (3.45 x 10-5 + 9.5 x 10-6) ÷ 0.0024
	2. 2.31 x 105 x 3.98 x 10-3 + 0.0013
5. Calculate the following:
	1. 20mm in metres
	2. 3.5kg in grams
	3. 589000 μm in metres
	4. 1m2 in cm2 (careful)
	5. 38 cm2 in m2
6. Find the following:
	1. 365 days in seconds, written in standard form
	2. 3.0 x 104 g written in kg
	3. 2.1 x 106 Ω written in MΩ
	4. 5.9 x 10-7 m written in μm
	5. Which is bigger? 1452 pF or 0.234 nF

Mark = /27

1. Significant Figures

Number in Physics also show us how certain we are of a value. How sure are you that the width of this page is 210.30145 mm across? Using a ruler you could not be this precise. You would be more correct to state it as being 210 mm across, since a ruler can measure to the nearest millimetre.

To show the precision of a value we will quote it to the correct number of significant figures. But how can you tell which figures are significant?

The Rules

1. All non-zero digits are significant.

2. In a number with a decimal point, all zeros to the right of the right-most non-zero digit are significant.

3. In a number without a decimal point, trailing zeros may or may not be significant, you can only tell from the context.

Examples

|  |  |  |
| --- | --- | --- |
| Value | # of S.F. | Hints |
| 23 | 2 | There are two digits and both are non-zero, so are both significant |
| 123.654 | 6 | All digits are significant – this number has high precision |
| 123.000 | 6 | Trailing zeros after decimal are significant and claim the same high precision |
| 0.000654 | 3 | Leading zeros are only placeholders |
| 100.32 | 5 | Middle zeros are always significant |
| 5400 | 2, 3 or 4 | Are the zeros placeholders? You would have to check how the number was obtained |

When taking many measurements with the same piece of measuring apparatus, all your data should have the same number of significant figures.

For example, measuring the width of my thumb in three different places with a micrometer:

20.91 x 10-3 m 21.22 x 10-3 m 21.00 x 10-3m **all to 4 s.f**

Significant Figures in Calculations

We must also show that calculated values recognise the precision of the values we put into a formula. We do this by giving our answer to the same number of significant figures as the least precise piece of data we use.

*There is no way we can state the runners speed this precisely.*

*For example:* A man runs 110 m in 13 s. Calculate his average speed.

Speed = Distance / Time = 110 m / 13 s = 8.461538461538461538461538461538 m/s

*This is the same number of sig figs as the time, which is less precise than the distance.*

 = 8.5 m/s to 2 s.f.

Significant Figures - Questions

1. Write the following lengths to the stated number of significant figures:
	1. 5.0319 m to 3 s.f.
	2. 500.00 m to 2 s.f.
	3. 0.9567892159 m to 2 s.f.
	4. 0.000568 m to 1 s.f.
2. How many significant figures are the following numbers quoted to?
	1. 224.4343
	2. 0.000000000003244654
	3. 344012.34
	4. 456
	5. 4315.0002
	6. 200000 stars in a small galaxy
	7. 4.0

**↑**

1. For the numbers above that are quoted to more than 3 s.f, convert the number to standard form and quote to 3 s.f.

4) Calculate the following and write your answer to the correct number of significant figures:

1. 2.65 m x 3.015 m
2. 22.37 cm x 3.10 cm
3. 0.16 m x 0.02 m
4. $\frac{54.401 m^{3}}{4 m}$

Mark = /19

1. Using Equations

You are expected to be able to manipulate formulae correctly and confidently. You must practise rearranging and substituting equations until it becomes second nature. We shall be using quantity symbols, and not words, to make the process easier.

Key points

* Whatever mathematical operation you apply to one side of an equation must be applied to the other.
* Don’t try and tackle too many steps at once.

Simple formulae

The most straightforward formulae are of the form $a =b ×c$ (or more correctly $ =bc$ ).

Rearrange to set b as the subject: Divide both sides through by c $\frac{a}{c} =\frac{b ×c}{c}$ therefore $\frac{a}{c} =b$

Rearrange to set c as the subject: Divide both sides through by b $\frac{a}{b} =\frac{b ×c}{b}$ therefore $\frac{a}{b} =a$

Alternatively you can use the formula triangle method. From the formula you know put the quantities into the triangle and then cover up the quantity you need to reveal the relationship between the other two quantities. This method only works for simple formulae, it doesn’t work for some of the more complex relationships, so you must learn to rearrange.

a

b

c

×

More complex formulae

|  |  |  |
| --- | --- | --- |
| Formulae with more than 3 terms | Formulae with additions or subtractions | Formulae with squares or square roots |
| **Find ρ** $R=\frac{ρl}{A}$Divide by l  $\frac{R}{l}=\frac{ρl}{Al}$Cancel l $\frac{R}{l}=\frac{ρl}{Al}$Multiply by A $\frac{R}{l}=\frac{ρl}{Al}$Cancel A $\frac{R}{l}=\frac{ρl}{Al}$ | **Find h** $Ek=hf-Φ$Add Φ $Ek+Φ=hf-Φ+Φ$Cancel Φ $Ek+Φ=hf$Divide by 𝑓 $\frac{Ek+Φ}{f}=\frac{hf}{f}$Cancel $f$ $\frac{Ek+Φ}{f}=h$ | **Find** $g$ $T=2π\sqrt{\frac{l}{g}}$Square $ T^{2}=4π^{2}\frac{l}{g}$Multiply by $g$  $gT^{2}=4π^{2}l$Divide by T2 $g=\frac{4π^{2}l}{T^{2}}$ |

|  |  |
| --- | --- |
| **Symbol** | **Meaning** |
| Δx | A change in x (difference between two values of x) |
| Δx/Δt | A rate of change of x |
| <x> or $\overbar{x}$ | Mean value of x |
| $$\vec{x}$$ | Quantity x is a vector |
| x1  x2 | Subscripts distinguish between same types of quantity |

Symbols on quantities

Sometimes the symbol for a quantity may be combined with some other identifying symbol to give more detail about that quantity. Here are some examples.

Using Equations - Questions

1. Make t the subject of each of the following equations:
2. V = u +at
3. S = ½ at2
4. Y = k (t - t0)
5. F = $\frac{mv}{t}$
6. Y = $\frac{k}{t^{2}}$
7. Y = 2t1/2
8. v = $\frac{Δs}{Δt} $

2) Solve each of the following equations to find the value of *t*:

1. 30 = 3t - 3
2. 4(t +5) = 28
3. $\frac{5}{t^{2}}$ = 10
4. 3t2 = 36
5. t -1/2 = 6
6. t1/3 = 3

Mark = /13

1. Straight Line Graphs

Value along x-axis

Value along y-axis

If a graph is a straight line, then there is a formula that will describe it. y = m x + c

y-intercept

gradient

Here are some examples:

1

2

3

4

5

6

-1

-2

-3

-4

-5

1

-6

2

3

4

5

6

-6

-5

-4

-3

-2

-1

0

y = x

y = 2x

y = x - 5

y = 2x + 4

y = -x + 1

y = x A positive line through the origin

 Gradient, m = 1 y-intercept, c = 0

y = x – 5 Parallel to y = x but transposed by -5.

 Gradient, m = 1 y-intercept, c = -5

y = 2x A positive line through the origin

 Gradient, m = 2 y-intercept, c = 0

y = 2x + 4 Parallel to y = 2x ,transposed by 4.

 Gradient, m = 2 y-intercept, c = 4

y = -x + 1 A negative line, parallel to y = -x

 Gradient, m = -1 y-intercept, c = 1

DIRECTLY PROPORTIONAL describes any straight line **through the origin**. Both y α x and Δy α Δx

LINEAR describes any other straight line. Only Δy α Δx.

Using Straight Line Graphs in Physics

If asked to plot a graph of experimental data at GCSE, you would plot the *independent variable* along the x-axis and the *dependent variable* up the y-axis. Then you might be able to say something about how the two variables are related.

At A-Level, we need to be cleverer about our choice of axes. Often we will need to find a value which is not easy to measure. We take a relationship and manipulate it into the form y = mx + c to make this possible.

*Example:* $R=\frac{ρl}{A}$ is the relationship between the resistance R of a conductor, the resistivity ρ of the material which it is made of, its length l, and its area A.

We do an experiment to find R, l and A, which are all easy to measure.

We want to find the resistivity ρ, which is harder.

gradient = ρ

y-intercept = 0

**𝑅**

**𝑙𝐴**

This example doesn’t need rearranging,

**y**

**m**

**x**

**+ c**

**𝑅**

**=**

**𝜌**

**𝑙𝐴**

just rewriting $R=\frac{ρl}{A}$ into the shape y = mx + c:

So it is found that by plotting R on the y-axis

and l/A on the x-axis, the resitivity 𝜌 will be

the gradient of the graph.

 Straight Line Graphs - Questions

1. For each of the following equations that represent straight line graphs, write down the gradient and the y intercept:
2. y = 5x + 6
3. y = -8x + 2
4. y = 7 - x
5. 2y = 8x - 3
6. y + 4x = 10
7. 3x = 5(1-y)
8. 5x - 3 = 8y

Mark = /14

1. Trigonometry

When dealing with vector quantities or systems involving circles, it will be necessary to use simple trigonometric relationships.

Angles and Arcs



There are two measurements of angles used in Physics.

* **Degrees** There are 360o in a circle
* **Radians** There are 2π radians in a circle

**Whichever you use, make sure your calculator is in the correct mode!**

To swap from one to the other you need to find what fraction of a circle you are interested in, and then multiply it by the number of degrees or radians in a circle.

$θ\_{radians}=\frac{θ\_{degrees}}{360}×2π$ or $θ\_{degrees}=\frac{θ\_{radians}}{2π}×360$

*For example:* To convert 90o into radians: $θ\_{radians} = \frac{θ\_{degrees}}{360}×2π = \frac{90}{360}×2π = \frac{1}{4}×2π = \frac{π}{2}radians$

 (We tend to leave answers in radians as fractions of π)

To find the length of an arc, use $s=θr$. The angle must be in radians. What would the relationship be if you wanted the entire circumference? Compare to this formula.

Sine, Cosine, Tangent

Recall from your GCSE studies the relationships between the lengths of the sides and the angles of right-angled triangles.



Using SOHCHATOA:

 $\sin(θ)= \frac{O}{H}$ $\cos(θ)= \frac{A}{H}$ $\tan(θ)= \frac{O}{A}$

Vector Rules

A **vector** is a quantity which has two parts: SIZE and DIRECTION

(e.g. force, velocity, acceleration)

A **scalar** is a quantity which just has SIZE

(e.g. temperature, length, time, speed)

We represent vectors on diagrams with arrows.

To simplify problems in mechanics we will separate a vector into horizontal and vertical components. This is done using the trigonometry rules.

Trigonometry - Questions

1. Calculate:
	1. The circumference of a circle of radius 0.450 m
	2. the length of the arc of a circle of radius 0.450m for the following angles between the arc and the centre of the circle:
		1. 340o
		2. 170o
		3. 30o



1. For the triangle ABC shown, calculate:
	1. Angle θ if AB = 30cm and BC = 40cm
	2. Angle θ if AC = 80cm and AB = 35cm
	3. AB if θ = 36° and BC = 50 mm
	4. BC if θ = 65° and AC = 15 km

3) Calculate the horizontal component A and the vertical component B of

a 65 N force at 40o above the horizontal.

Mark = /10

1. Exam Technique

It is vital that you are able to communicate a numerical answer appropriately to an examiner.

Students will often make these mistakes in questions that involve calculations:

* Copying values or equations incorrectly from the question or the data sheet.
* Mistakes when rearranging formulae.
* Ignoring prefixes to units.
* Inputting into calculator wrong, especially standard form and accurate use of brackets.
* Having the calculator in the wrong mode (radians/degrees)
* If asked for, not writing final answer to the correct number of significant figures or writing the unit.
* Writing down a value which would be silly in the context of the question.
* Messy working that is difficult to decipher.

A method for numerical questions

c = 3.00 x 108 ms-1

h = 6.63 x 10-34 Js

E = 0.199 pJ

 = 0.199 x 10-12 J

λ = ?

E = $\frac{hc}{λ}$

λ = $\frac{hc}{E}$

 = $\frac{6.63 × 10^{-34}Js × 3.00 × 10^{8} ms^{-1}}{0.199 ×10^{-12}J}$

 = ~~9.9949 x 10~~11 ~~m~~

 = 9.99 x 10-13 m to 3 s.f.

*Data sheet:*

Speed of electromagnetic radiation in free space, c = 3.00 x 108 m s-1

Planck’s constant, h = 6.63 x 10-34 J s

*Example question:*

Calculate the wavelength of a quantum of electromagnetic radiation with energy of 1.99 pJ.

(1) Write down the values of everything you are given.

(2) Convert all the values into SI units (e.g. put time into seconds, distance in meters...) and replace unit prefixes with their equivalent values in standard form.

(3) Pick the equation you need. If you need to find it on the data sheet, look for one that contains the quantities you know and the quantity you are trying to work out.

(4) Rearrange the formula so the quantity you want is the subject of the equation.

(5) Insert the values into your equation, taking care to lay out your working clearly

(6) Use your calculator to accurately input the numbers to find the solution.

(7) Write down the answer to more decimal places than you need at first, in case you need the value for later calculations. Check the answer seems sensible. In this example I got a massive wavelength the first time because I mistyped the energy as 0.199 x 10**12** J.

(8) Write your final answer and underline it. All the input values were to 3 s.f., so the answer should be written to the same precision.

1. Terms and Definitions

You need to be confident about the definitions of terms that describe measurements and results in A Level Physics.

Create a quizlet ([https://quizlet.com](https://quizlet.com/en-gb)) or make a series of flashcards for the information below and then use this resource to learn the terms and definitions. Keep this it will be helpful in the future!!

You may be tested on some of these in the first lesson!!

|  |  |
| --- | --- |
| When is a measurement valid? | when it measures what it is supposed to be measuring |
| When is a result accurate? | when it is close to the true value |
| What are precise results? | when repeat measurements are consistent/agree closely with each other |
| What is repeatability? | how precise repeated measurements are when they are taken by the *same* person, using the *same* equipment, under the *same* conditions |
| What is reproducibility? | how precise repeated measurements are when they are taken by *different* people, using *different* equipment |
| What is the uncertainty of a measurement? | the interval within which the true value is expected to lie |
| Define measurement error | the difference between a measured value and the true value |
| What type of error is caused by results varying around the true value in an unpredictable way? | random error |
| What is a systematic error? | a consistent difference between the measured values and true values |
| What does zero error mean? | a measuring instrument gives a false reading when the true value should be zero |
| Which variable is changed or selected by the investigator? | independent variable |
| What is a dependent variable? | a variable that is measured every time the independent variable is changed |
| Define a fair test | a test in which only the independent variable is allowed to affect the dependent variable |
| What are control variables? | variables that should be kept constant to avoid them affecting the dependent variable |
| What is an atom made up of? | a positively charged nucleus containing protons and neutrons, surrounded by electrons |
| Define a nucleon | a proton or a neutron in the nucleus |
| What are the absolute charges of protons, neutrons, and electrons?  | + 1.60×10−19, 0, and − 1.60×10−19 coulombs (C) respectively |
| What are the relative charges of protons, neutrons, and electrons? | 1, 0, and − 1 respectively (charge relative to proton) |
| What is the mass, in kilograms, of a proton, a neutron, and an electron?  | 1.67×10−27, 1.67×10−27, and 9.11×10−31 kg respectively |
| What are the relative masses of protons, neutrons, and electrons? | 1, 1, and 0.0005 respectively (mass relative to proton) |
| What is the atomic number of an element? | the number of protons |
| Define an isotope | isotopes are atoms with the same number of protons and different numbers of neutrons |
| Write what A, Z and X stand for in isotope notation ()? | A: the number of nucleons (protons + neutrons)Z: the number of protonsX: the chemical symbol |
| Which term is used for each type of nucleus? | nuclide |
| How do you calculate specific charge?  | charge divided by mass (for a charged particle) |
| What is the specific charge of a proton and an electron?  | 9.58×107 and 1.76×1011 C kg−1 respectively |
| Name the force that holds nuclei together | strong nuclear force |
| What is the range of the strong nuclear force? | from 0.5 to 3−4 femtometres (fm) |
| Name the three kinds of radiation | alpha, beta, and gamma  |
| What particle is released in alpha radiation? | an alpha particle, which comprises two protons and two neutrons |
| Write the symbol of an alpha particle |  |
| What particle is released in beta radiation? | a fast-moving electron (a beta particle) |
| Write the symbol for a beta particle |  |
| Define gamma radiation | electromagnetic radiation emitted by an unstable nucleus |
| What particles make up everything in the universe? | matter and antimatter |
| Name the antimatter particles for electrons, protons, neutrons, and neutrinos | positron, antiproton, antineutron, and antineutrino respectively |
| What happens when corresponding matter and antimatter particles meet? | they annihilate (destroy each other) |
| List the seven main parts of the electromagnetic spectrum from longest wavelength to shortest | radio waves, microwaves, infrared, visible, ultraviolet, X-rays, gamma rays |
| Write the equation for calculating the wavelength of electromagnetic radiation | wavelength (λ) =  |
| Define a photon | a packet of electromagnetic waves |
| What is the speed of light? | 3.00×108 m s−1 |
| Write the equation for calculating photon energy | photon energy (E) = Planck constant (h) × frequency (f) |
| Name the four fundamental interactions | gravity, electromagnetic, weak nuclear, strong nuclear |