



A level Physics Year 11-year 12 Transition Summer workbook

Background maths and problem solving skills

This work is designed to help prepare you for A-level physics. It covers some of the basic skills that will be used throughout the course. Many of these extend and develop ideas you will have come across at GCSE in science and maths. You will need to use a combination of **careful reading, research, logic** and **persistence**. You should expect to find some parts difficult, but if you persevere you will often find you can do them!

Please complete as much of this booklet as possible. Do your workings and answers on paper and hand this in during the first week of teaching in September.

Unit Prefixes

Prefixes are written in front of units to indicate multiplication or division by multiples factors of 1000. So mega means $\times 1,000,000$. (One exception is 'centi', as in cm, which means divide by 100)

YOU MUST LEARN THE PREFIXES BY HEART AND BECOME ADEPT AT USING THEM.

1. Complete the following table. (You will need to research some of the missing units).

Symbol		Multiplier	Which means...
	terra		
		$\times 10^9$	
M			$\times 1,000,000$
k			$\times 1000$
(None)	---	---	$\times 1$
m			
	micro		$/ 1,000,000$
n			
		$\times 10^{-12}$	
f			

2. Expand each of these quantities to write out the answer in full (i.e. without the prefixes)

- a) 900 mV =
- b) 12 MJ =
- c) 1.67 mm =
- d) 3.456 kg =
- e) 700 nm =
- f) 0.72 pA =

3. Write each of the following using an appropriate prefix:

- a) 0.005 A =
- b) 30000 s =
- c) 5×10^5 m =
- d) 1001 m =
- e) 0.006 V =
- f) 2,100,000 N =

4. Convert each of the following to the indicated units:

- a. 34 nm =mm
- b. 0.012 s = μ s
- c. 4.5 MJ =kJ

1. UNITS (a) The SI system of units

Scientific measurement depends on standard units – most are Système International (SI) units. Every measurement must give the unit to have any meaning. You should know the correct unit for physical quantities.

Base units

Physical quantity	Unit	Symbol
Length	metre	m
mass	kilogram	kg
time	second	s

Physical quantity	Unit	Symbol
electric current	ampere	A
temperature difference	Kelvin	K
amount of substance	mole	mol

Derived units

Example:

$$\text{speed} = \frac{\text{distance travelled}}{\text{time taken}}$$

If a car travels 2 metres in 2 seconds:

$$\text{speed} = \frac{2 \text{ metres}}{2 \text{ seconds}} = 1 \frac{\text{m}}{\text{s}} = 1 \text{ m/s}$$

This defines the SI unit of speed to be 1 metre per second (m/s), or 1 m s^{-1} ($\text{s}^{-1} = \frac{1}{\text{s}}$).

Physical quantity	Equation used to derive unit	Unit	Symbol and name (if there is one)
frequency	period ⁻¹	s ⁻¹	Hz, hertz
volume	length ³		–
density	mass ÷ volume		–
acceleration	velocity ÷ time		–
force	mass × acceleration		
work and energy	force × distance		

MATHS – Powers of 10 and standard form

You need to be able to use your calculator to work in standard form or use power of ten notation to replace unit suffixes.

[Tip: you should use the [x10^x] or [EXP] button on your calculator for entering powers of ten.]

1. Rewrite these numbers in standard form, removing any unit prefixes:

a) 3141

b) .00055

c) 2.0002

d) 120000 (2sf)

e) 120000 (6sf)

f) 843×10^4

g) 1.5 μm

h) $12.0 \times 10^{-2} \text{ nm}$

i) 999 MJ

j) 245 mg

k) 16 pF

l) 97.237 GN

All of the equations we use in Physics require variables to be converted to standard SI units. This means any prefixes must first be removed. For example to calculate resistance in ohms (Ω) you divide the p.d. in volts (V) by the current in amps (A), If current = 8.0 mA (milliamps) and the voltage was 12 kV (kilovolts) the correct calculation would be:

$$R = V/I = 12 \times 10^3 / 8.0 \times 10^{-3} = 1.5 \times 10^6 \Omega$$

Try the above on your calculator before you continue.

- f) Force, $F = m a = 923000\text{g} \times 9.8 \text{ m}\cdot\text{s}^{-2}$

4. Complete each of the following calculations using your calculator, giving your answer in standard form with the correct number of significant figures, with your answer in the units indicated.

- (a) $\rho = m / V = 0.542 \text{ g} / 0.027 \text{ cm}^3 = \dots\dots\dots \text{g} \cdot \text{cm}^{-3}$
- (b) $E = m c^2 = 231.5 \times 10^{-3} \times (3.00 \times 10^8)^2 = \dots\dots\dots \text{J}$
- (c) Mean time = $(23 + 20 + 21 + 22 + 25) / 5 = \dots\dots\dots \text{s}$
- (d) Height difference = $2.32\text{m} - 2.07\text{m} = \dots\dots\dots \text{m}$

5. Complete the following calculations using a calculator, showing your working and giving an answer in standard form to the correct number of significant figures, in appropriate units:

a) $\frac{2.3 \times 6.5}{3.7 \times (9.1)^2}$	b) $(314)^3 / (9.9^2)$	c) $(12 \times 45\text{g}) / 12 \text{ cm}^3$
d) $1.2 \times 10^{-6} \times 1.5 \times 10^{-4}$	e) $(16 \text{ m} \cdot \text{s}^{-1})^2$	f) $923\text{Kg} \times 9.8 \text{ m} \cdot \text{s}^{-2}$
g)	h)	i)

2. REARRANGING EQUATIONS

Rearrange these equations to express them in the terms that follow:

- | | | | |
|--|------------------|--------------|------------|
| 1. $v = x / t$ | a. $x = ?$ | b. $t = ?$ | |
| 2. $F = m a$ | a. $m = ?$ | b. $a = ?$ | |
| 3. $a = (v - u) / t$ | a. $t = ?$ | b. $v = ?$ | c. $u = ?$ |
| 4. $v^2 = u^2 + 2as$ | a. $v = ?$ | b. $a = ?$ | c. $u = ?$ |
| 5. $s = ut + \frac{1}{2} a t^2$ | a. $u = ?$ | b. $a = ?$ | c. $t = ?$ |
| 6. $\frac{1}{R_{tot}} = \frac{1}{R_1} + \frac{1}{R_2}$ | a. $R_{tot} = ?$ | b. $R_1 = ?$ | |

3. Showing your working clearly

When answering physics questions you need to lay out your working clearly showing all the steps, working left to right and top to bottom. Your final answer should be found to the bottom right of your working and should be underlined. Below is an example for you to base your own answer style on.

Ques: A white snooker ball with a kinetic energy of 15J collides with a red ball. On impact the white ball stops, transferring all of its KE to the red ball. The mass of the red ball is 120 g. What would be the velocity of the red ball immediately following the collision?

STEPS: Equation being used → rearrange → values inserted
→ calculated answer → units → sig fig

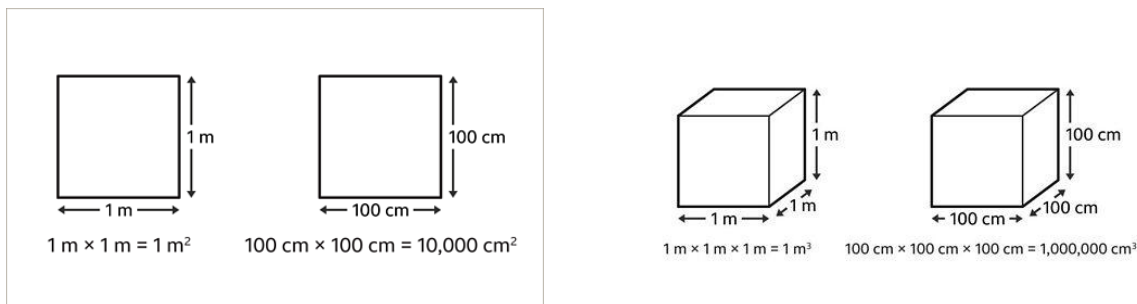
$$KE = \frac{1}{2}mv^2 \quad \therefore \quad \frac{2KE}{m} = v^2 \quad \therefore \quad v = \sqrt{\frac{2 \times 15J}{0.12kg}}$$

$$= 15.8 \text{ ms}^{-1} = \underline{16 \text{ ms}^{-1} (2sf)}$$

EIGHT STEPS TO IMPROVE THE QUALITY OF YOUR WORKING

- ☐ Show all steps
- ☐ Work left to right and top to bottom
- ☐ Rearrange equations before substituting values
- ☐ If a calculation is two step, underline the answer to the first step before proceeding as this may get marks
- ☐ Your writing should be small and neat. Don't scrawl.
- ☐ You should be able to easily check over your working to find mistakes
- ☐ Plan to use the available answer space wisely
- ☐ Try to leave space for correcting mistakes if you go wrong

TIP – when converting square and cube units – sketch a quick square or cube and check you have the correct conversion factor!



4. Bringing it all together

Brain-gym for the physics-muscle in your head (It hurts to start with, but gets easier with practise)

These problems will challenge you to work with powers and units, rearrange equations and use your calculator carefully. Helpful formulae for volume and surface area are given on the last page, as are the answers.

Lay out your working clearly, work step by step, and check your answers. If you get one wrong, go back and try again. Do not be disheartened if they seem difficult to start with, persevere and seek help – you will improve. Importantly, have fun!

1. How many mm² are there in

(a) 1cm²?

(b) 1 m²?

(c) 1 km²?

2. How many cm³ are there in

(a) 1mm³ ?

(b) 1 m³?

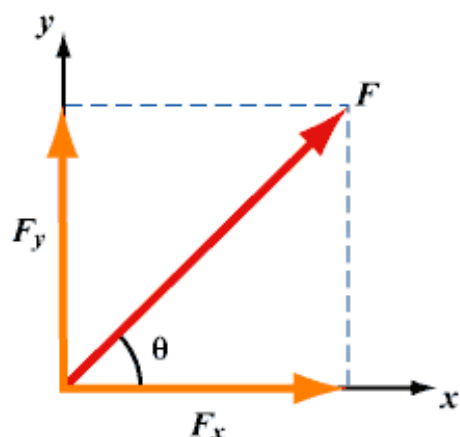
3. A piece of A4 paper is 210×297 mm. All measurements are to the nearest mm. Calculate its area in (a) mm^2 , (b) cm^2 , (c) m^2 . Give answers to the correct number of significant figures.
- a) Area = mm^2
- b) Area = cm^2
- c) Area = m^2
4. A plastic toy is supplied in a cubic box, 4.0 cm each side. How many of them pack into a carton $80 \times 52 \times 70$ cm? (Students often get the wrong answer and can't see why. Visualise the actual problem don't just rely on maths!)
5. A copper atom has a diameter of 217 pm (pico-meters). How many of them would fit inside 1mm^3 of copper to 3 sig. fig? (Tip: for simplicity, treat them as cubes of side 217 pm)
6. Water has a density of 1.0 g cm^{-3} . Express this in (a) kg cm^{-3} , (b) kg m^{-3} , (c) kg mm^{-3}
- a) Density = kg cm^{-3}
- b) Density = kg m^{-3}
- c) Density = kg mm^{-3}
7. A regular block of metal has sides $12.2 \times 3.7 \times 0.95$ cm, and a mass of 107g. Find its density in Kg m^{-3} to a suitable number of significant figures.
8. A measuring cylinder is filled with 1.00 litres of water. The column of water inside forms a regular cylinder 32.0 cm high. What is (a) the area of the surface of the water (in mm^2)? (b) the internal diameter of the cylinder (in mm)?
(TIP: Visualise the problem clearly. Draw a diagram if it helps. Use the equation or the volume of a cylinder)
9. The diameter of the sun is 1.4×10^6 km. Its average density is 1.4 g cm^{-3} . What is its mass in kg?
(TIP: The trick here is to convert the units carefully before you start)
10. The total energy arriving in the Earth's upper atmosphere from the sun is 174×10^{15} Watts. Given that the Earth's diameter is 12.8×10^3 km, what is the average intensity of this radiation in W m^{-2} ?
(TIP: Think about the units carefully. What does W m^{-2} mean?)

GEOMETRICAL EQUATIONS

arc length	$= r\theta$
circumference of circle	$= 2\pi r$
area of circle	$= \pi r^2$
surface area of cylinder	$= 2\pi rh$
volume of cylinder	$= \pi r^2 h$
area of sphere	$= 4\pi r^2$
volume of sphere	$= \frac{4}{3} \pi r^3$

Answers:
1. a) 10^2 (100) b) 10^6 (1,000,000) c) 10^{12}
2. a) 10^{-3} (1/1000) b) 10^6 (1,000,000)
3. a) $6.237 \times 10^4 \text{ mm}^2$ (62,370 mm^2) b) $6.237 \times 10^2 \text{ cm}^2$ (623.7 cm^2) c) $6.237 \times 10^{-2} \text{ m}^2$ (0.06237 m^2)
4. 4420
5. 9.79×10^{19}
6. a) $1 \times 10^{-3} \text{ kg cm}^{-3}$ b) $1 \times 10^3 \text{ kg m}^{-3}$ c) $1 \times 10^{-6} \text{ kg mm}^{-3}$
7. $2.50 \times 10^3 \text{ kg m}^{-3}$
8. a) 3125 mm^2 b) 62.4 mm

KS4 Revision & Extension



Resolving vectors

In A level Physics you will need to work with vectors that act at odd angles. Often the easiest way to deal with this is to convert the diagonal vector into horizontal and vertical components.

For example, in the case of a force F acting at an angle θ , can be treated as two forces acting horizontally (F_x) and vertically (F_y). These can be calculated with trigonometry:

$$F_y = F \sin(\theta) \quad \text{and} \quad F_x = F \cos(\theta)$$

You may need to use this in the following questions

In the following calculations take $g = 9.8 \text{ N kg}^{-1}$

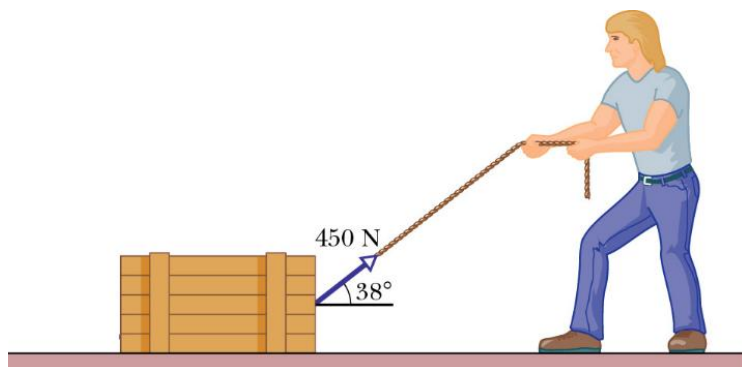
- 1) Calculate the work done in each of the following situations, stating the final form of the transferred energy.

- i) A box is pushed 3m along the floor by a horizontal force of 500N

Work = J Energy is transferred into.....(2)

- ii) An electric lift raises 540 kg load through a height of 18.3 metres

Work = J Energy is transferred into.....(3)



- iii) A man uses a rope to pull a box along a floor, as shown above. He drags the box 3.0 km.

Work done = J Energy is transferred into..... (4)

- iv) A student adds three 100g slotted masses to a spring of spring constant, $k = 6.0 \text{ Nm}^{-1}$. It extends by 14.0 cm.

Work done = J Energy is transferred into..... (4)

2) Which of the following are units of power? (circle all of the correct units)

joule second watt joule second⁻¹ newton metre second⁻¹ amp volt

(2)

Explain why power is equal to force × velocity

(2)

Explain why power is equal to current × potential difference

(2)

3) In two minutes a rocket gained 370 MJ of kinetic energy and 1300 MJ of gravitational potential energy.

i) Find the useful power produced by the rocket engines.

Power = W (2)

ii) In the following 30 seconds the rocket travels at a steady speed of 320 ms⁻¹. Assuming the power of the engines to be constant, calculate the thrust force produced by the engines.

Force = N (2)

4) A 12V electric motor is used to lift a 50g mass through 1.0m. The overall efficiency of this system is 10%.

Whilst in operation it draws a current of 0.25A.

i) Find the useful power output of the electric motor.

Power = W (2)

ii) How long does it take the motor to raise the mass 1.0m?

Time = s (2)

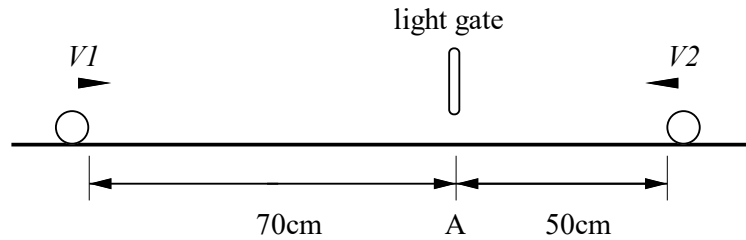
SPEED QUESTIONS

1. A bullet travels 300m in 2.60 seconds what is its velocity in (a) m s⁻¹ (b) km h⁻¹ ?

2. An alpha particle covers 2.0 cm travelling at 5% the speed of light (speed of light=3.0 x10⁸ m s⁻¹). How long does it take to cover this distance?

3. A cyclist is racing on a circular track at an average speed of 8.35 m s⁻¹. She completes three laps in 2 minutes 24.36 seconds. What is the radius of the track?

4. Two pool balls are moving towards each other as in the diagram below. At position A is a light gate.



If $V1 = 0.60 \text{ m s}^{-1}$ and $V2 = 0.20 \text{ m s}^{-1}$ then (a) which ball passes through the light gate first and (b) at what time and (c) at what position do they collide and (d) at what time?

5. A light-year is the distance light travels in one year. Calculate this distance in metres to 3 significant figures, given that the speed of light is $3.00 \times 10^8 \text{ m s}^{-1}$.

ACCELERATION QUESTIONS

6. A horse is cantering at 3.1 m s^{-1} and breaks into a gallop reaching a speed of 5.6 m s^{-1} in 3.5 seconds. Calculate its acceleration.
7. A car travelling at 16.0 m s^{-1} , brakes for 3.20 s, decelerating at a rate of 3.125 m s^{-2} . What is its final speed?
8. An Olympic diver strikes the water at a speed of 7.2 m s^{-1} , and comes to rest in 1.2 seconds. What is his acceleration?
9. A falling ball strikes a floor with a velocity of 4.2 m s^{-1} and rebounds with a velocity of -3.8 m s^{-1} . It is in contact with the floor for 0.12 seconds. What was its acceleration?
10. A Porsche is quoted as having a "*0-60 time of 4.2 seconds*". This means it accelerates from zero to 60 miles per hour in 4.2 seconds. Given that 1 mile = 1.55 km, calculate its acceleration in ms^{-2} .
11. At the University of Errors Science Tower, a brick is observed falling past the window of the physics laboratory. A quick thinking physics student records its speed as 4.59 m s^{-1} . A moment later it passes the ground floor windows of the engineering faculty and an alert engineer records its speed as 12.91 m s^{-1} .
- (a) Assuming acceleration due to gravity to be 9.81 m s^{-1} and assuming air resistance to be
- (b) By considering its average speed calculate the height between the Physics and the Engineering labs.