

GCSE to A level Physics Transition 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!

YOU MAY USE A CALCULATOR THROUGHOUT

Name:

Please complete as much of this booklet as possible, including the self-assessment below, then hand in during the first week of teaching in September.

Confidence:

A = all parts correct and understood

C = some parts correct and mostly understood

E = few parts correct or poorly understood

	Self Assessment		
	Mark	Confidence (A-E)	ISSUES / COMMENTS
1. Expectations – read and remember!	---		
2. Unit Prefixes – complete table + questions/25		
3. (a) SI system of units – complete table (b) Derived units – complete table/11		
4. Maths-powers of ten and standard form – complete calculations/18		
5. Significant figures – read + complete calculations			
6. Rearranging equations/10		
7. Showing your working – read			
8. Bringing it all together – How many of these challenging questions did you crack?/10		
9. Revise and Extend: Energy and Power/30		
10. Revise and Extend: Speed and Acceleration/30		

1. Expectations

Attendance

1. Attend every lesson
2. Arrive on time
3. Ensure any assignments due are complete and presentable – no excuses

Equipment

4. Bring the following equipment every lesson:
 - a. Exercise books
 - b. pen, pencil, ruler (30cm), protractor, compasses
 - c. Scientific calculator
 - d. Textbook

Private study & Assignments

5. Plan to spend roughly an equal time studying physics outside class as inside.
6. Some of this time will be for assignments ('homework'), the rest for reading around the subject, practicing questions, writing up practicals and improving your notes.
7. Record homework and deadlines clearly.
8. Expect homework at the end of every session – if you are not sure what it is ask.
9. Make a note of anything you get stuck on or do not understand.
10. Don't always work alone - working with a physics partner can be very effective (not one person copying another, but arguing and thinking a problem out together)

In Class

11. **Be proactive:** ask for help if there is anything you don't understand, don't let an idea remain vague ask, think and question until it becomes clear – it will!
12. **Interact:** put your hand up & ask questions as much as possible – don't leave it to others.
13. **Be efficient:** don't waste time chatting or being off task – you will drag yourself and others down if you do.
14. **Listen:** pick up on all the tips and advice then put them into practice, don't ignore them.

2. 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 WORKING WITH 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 = | d. 3.456 kg = |
| b. 12 MJ = | e. 700 nm = |
| c. 1.67 mm = | f. 0.72 pA = |

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

- | | |
|------------------------|------------------|
| g. 0.005 A = | j. 1001 m = |
| h. 30000 s = | k. 0.006 V = |
| i. 5×10^5 m = | l. 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 |

3. UNITS (a) The SI system of units

- Look up the following terms and write a few sentences about each:

Physical Quantities	
SI Units	
Base Units	
Derived Units	

- In physics all units can be derived from six base units. Research how the base units are defined.

Base Quantity	Base Unit	Definition (Note: you do not need to learn these definitions)
Length	metre (m)	
Mass	kilogram (kg)	
Time	second (s)	
Temperature	kelvin (K)	
Current	ampere (A)	

3. UNITS (b) Derived units

In physics all non-base quantities are called **derived quantities** and are defined by equations.

E.g. (a) Define speed. (b) Define charge.

(a) speed = distance / time **(b) charge = current × time.**

The units of these new quantities are **derived units** and are established from these same equations. So,

(b) The unit of speed = unit of distance / unit of time = m / s = m·s⁻¹ ('metres per second')*

(c) The unit of charge = the unit of current × the unit of time = A·s ('amp second')

*NOTE: At A level we write divided units, such as 'metres per second' as ms⁻¹ **not** m/s.

In the SI system, many of these derived units get their own name. For example, the SI unit of charge is the coulomb (C). So we can say that one coulomb is equal to one amp second.

or **C = A s**

Any SI unit can be expressed in terms of base units. To find the base units work through the defining equations one by one, until you end up with the base units. For example, what are the base units of a Joule? This requires two steps:

- Energy (Work) = Force × distance moved, So one joule = one newton metre (**J = N·m**)
- Force is defined from $F = m a$, so one newton = one kilogram metre per second squared (or **N = kg·m·s⁻²**)
- Therefore, a joule = **N m = (kg·m·s⁻²) m = kg·m²·s⁻²**

1. Complete the table below.

Try working these out rather than looking them up. You can use the earlier answers to help with the harder ones.

Derived quantity	Defining equation	Standard SI unit (if applicable)	Equivalent base units
speed	$S = d / t$	n/a	$m \cdot s^{-1}$
momentum	$p = m v$	n/a	$kg \cdot m \cdot s^{-1}$
acceleration	$a = (v - u) / t$	n/a	
Force	$F = m a$	newton (N)	
Power	power = work/time $P = W/t$		
frequency	frequency = 1/time period $f = 1 / T$		s^{-1}
Charge	charge = current × time $Q = I t$	coulomb (C)	A s
potential difference	voltage = work/charge $V = W/Q$		
resistance	$R = V / I$		
specific heat capacity	SHC = Energy / (mass × temperature change) $c = Q / (m \times \theta)$		

4. MATHS – Powers of 10 and standard form (aka scientific notation)

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] button on your calculator for entering powers of ten.]

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

a) 3141

.....

d) 120000 (2sf)

.....

g) 1.5 μm

.....

j) 245 mg

.....

b) .00055

.....

e) 120000 (6sf)

.....

h) 12.0 × 10⁻² nm

.....

k) 16 pF

.....

c) 2.0002

.....

f) 843 × 10⁴

.....

i) 999 MJ

.....

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.

2. Calculate the following showing your working, giving the answers in appropriate units. (This means removing suffixes, except for grams which need to be converted to kg)

a) Area (m²) = 120 mm × 250 mm

b) Area (m²) = 2.4 m × 60 cm

c) Density (kg·m⁻³) = 48 g / 12 cm³

d) Charge in coulombs, Q=I t
= 3.0 × kA × 20 μs

e) Speed squared, v² = (16 m·s⁻¹)²

f) Force, F = m × a
= 923000g × 9.8 m·s⁻²

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) $923\text{Kg} \times 9.8 \text{ m}\cdot\text{s}^{-2}$

6. 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. $\frac{1}{R_{tot}} = \frac{1}{R_1} + \frac{1}{R_2}$
 $= ? R_{tot} R_1 R_2$

a. $R_{tot} = ?$

a. R_1

7. 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.

Ch6, Q4

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

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

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

EIGHT STEPS TO IMPROVE THE QUALITY OF YOUR WORKING

- | | |
|--|--|
| <ul style="list-style-type: none"> <input type="checkbox"/> Show all steps <input type="checkbox"/> Work left to right and top to bottom <input type="checkbox"/> Rearrange equations before substituting values <input type="checkbox"/> If a calculation is two step, underline the answer to the first step before proceeding as this may get marks | <ul style="list-style-type: none"> <input type="checkbox"/> Your writing should be small and neat. Don't scrawl. <input type="checkbox"/> You should be able to easily check over your working to find mistakes <input type="checkbox"/> Plan to use the available answer space wisely <input type="checkbox"/> Try to leave space for correcting mistakes if you go wrong |
|--|--|

8. Bringing it all together

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

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}

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.....

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) $1 \times 10^6 \text{ kg m}^{-3}$ 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) 63.1 mm
9.	$2.0 \times 10^{30} \text{ kg}$
10.	338 W m^{-2}

KS4 Revision & Extension

9. Energy and Power

Look up definitions for each of the following quantities and write down the equations and any notes you think are helpful

Work

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Kinetic Energy

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Gravitational Energy

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Elastic Potential Energy

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Efficiency

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Power (including electrical power)

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What is the definition of work?

.....
.....

In the following calculations take $g = 9.81 \text{ N kg}^{-1}$

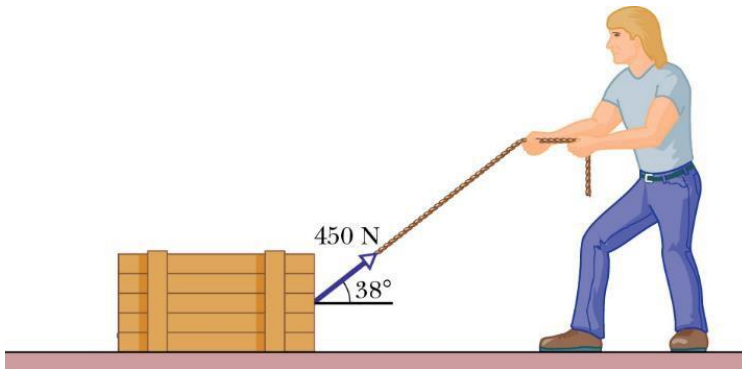
1) Calculate the work done in each of the following situations, stating the final form of the transferred energy.

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

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

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

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.....
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.

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.....
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.

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

Power

What is the definition of power?

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..... (1)

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

.....
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..... (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.

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..... 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} ?

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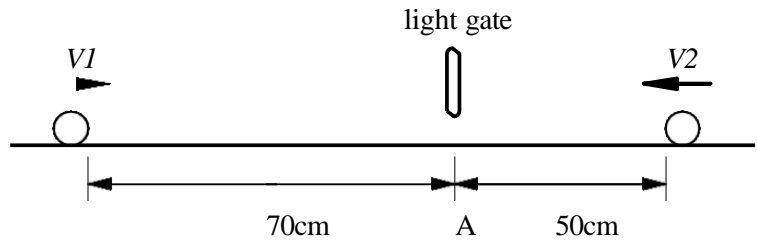
2. An alpha particle covers 2.0 cm travelling at 5% the speed of light (speed of light= $3.0 \times 10^8 \text{ m s}^{-1}$). How long does it take to cover this distance?

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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?

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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?

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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 $3.00 \times 10^8 \text{ m s}^{-1}$.

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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.

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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?

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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?

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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?

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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}

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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 negligible, how long was the 'moment' between these observations?

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(b) By considering its average speed calculate the height between the Physics and the Engineering labs.

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