Physics A Level

OCR A

TENACITY

Year 12 Transition Booklet

Name ___________________________________

📘 A Level Physics – Transition Work

Complete the tasks either in the booklet or on paper.

Answers to sections 1-7 are at the back. Please mark and correct these.

If you need additional paper/graph paper please let me know.

Contents – Skills Tracker

Topic	Title	Completed (date)	Comments More practice? Confident?
1	Prefixes and Units		
2	Significant Figures		
3	Converting Length, Area and Volume		
4	Rearranging Equations		
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1. Prefixes and Units

Introduction

In Physics we have to deal with quantities from the very large to the very small.
A **prefix** is something that goes in front of a unit and acts as a multiplier.

SI Prefix Table

Symbol	Name	Power	Value	Convert Up	Convert Down
P	peta	10^{15}	1000000000000000		↓ ×1000
T	tera	10^{12}	1000000000000	↑ ÷1000	↓ ×1000
G	giga	10^{9}	1000000000	↑ ÷1000	↓ ×1000
M	mega	10^{6}	1000000	↑ ÷1000	↓ ×1000
k	kilo	10^{3}	1000	↑ ÷1000	↓ ×1000
—	—	10^{0}	1	↑ ÷1000	↓ ×1000
m	milli	10^{-3}	0.001	↑ ÷1000	↓ ×1000
µ	micro	10^{-6}	0.000001	↑ ÷1000	↓ ×1000
n	nano	10^{-9}	0.000000001	↑ ÷1000	↓ ×1000
p	pico	10^{-12}	0.000000000001	↑ ÷1000	↓ ×1000
f	femto	10^{-15}	0.000000000000001	↑ ÷1000	

Conversions Practice

Convert into base units

Given	=	Answer
6 km	=	6×10^3 m
54 MN	=	
0.086 μV	=	
753 GPa	=	
23.87 mm s^{-1}	=	

Convert into suitable prefixed units

Given	=	Answer
640 GV	=	640×10^9 V
_______	=	0.5×10^{-6} A
_______	=	93.09×10^9 m
kN	=	32×10^5 N
nm	=	0.024×10^{-7} m

Time Conversions

s	ms	µs	ns	ps
0.00045	0.45	450	450000 or 450×10^3	450×10^6
0.000000789				
0.00000000064				

Length Conversions

mm	m	km	µm	Mm
1287360				
295				

Wave Equation

$$\text{wave speed} = \text{frequency} \times \text{wavelength}$$
$$v = f\lambda$$

Units:

- Velocity: m s^{-1}
- Frequency: Hz
- Wavelength: m

Important Conventions

- Always use **SI units**
- Use index notation:
    - m/s → m s^{-1}
    - m/s^2 → m s^{-2}
- Leave **one space between number and unit**
    - ✓ 10 m
    - ✗ 10m
- No space between prefix and unit

Ambiguity Example

- ms^{-1} = millisecond^{-1}
- m s^{-1} = metres per second

Worked Example

$$\begin{aligned} v &= f\lambda \\ &= 75 \times 10^{12} \times 4.0 \times 10^{-6} \\ &= 3.0 \times 10^{8}\ \text{m s}^{-1} \end{aligned}$$

(= 300 Mm s^{-1})

Questions

- Calculate the speed (m s^{-1}) of a wave with frequency 75 THz and wavelength 4.0 μm
- Calculate the speed (m s^{-1}) of a wave with wavelength 5.6 mm and frequency 0.25 MHz
- Calculate the wavelength (m) for a wave travelling at 0.33 km s^{-1} with frequency 3.0 GHz
- Calculate the frequency (Hz) for a wave travelling at 300×10^{3} km s^{-1} with wavelength 0.050 mm
- Calculate the frequency (GHz) for a wave travelling at 300 Mm s^{-1} with wavelength 6.0 cm

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2. Significant Figures

Rules

1. **All non-zero numbers ARE significant**
   - 33.2 → 3 significant figures
2. **Zeros between digits ARE significant**
   - 2051 → 4 significant figures
3. **Leading zeros are NOT significant**
   - 0.54 → 2 significant figures
   - 0.0032 → 2 significant figures
4. **Trailing zeros (with decimal) ARE significant**
   - 92.00 → 4 significant figures
   - 230.0 → 4 significant figures
5. **Trailing zeros (no decimal) are NOT necessarily significant**
   - 540 → 2 significant figures

⚠️ This can cause ambiguity — scientific notation is preferred.

1. **Scientific notation rule**
   In $N \times 10^x$:
   - Only digits in **N** are significant
   - Example: 5.02×10^4 → 3 significant figures

Practice Table

Value	Sig Figs	Value	Sig Figs	Value	Sig Figs	Value	Sig Figs
2		1066		1800.45		0.070	
2.0		82.42		2.483×10^4		69324.8	

500		750000		0.0006		0.0063	
0.136		310		5906.4291		9.81×10^4	
0.0300		3.10×10^4		200000		40000.00	
54.1		3.1×10^2		12.711		0.0004×10^4	

Addition and Subtraction

Rule:
Round to the **least number of decimal places**

Example:

$$0.88 + 10.2 - 5.776 = 5.304 \rightarrow 5.3$$

Practice

Value 1	**Value 2**	**Value 3**	**Total**	**Rounded**
51.4	1.67	3.23		
7146	-32.54	12.8		
20.8	18.72	0.851		
1.4693	10.18	-1.062		

Multiplication and Division

Rule:
Round to the **least number of significant figures**

Example:

$$4.02 \times 3.1 \div 0.114 = 110$$

Multiplication Practice

Value 1	Value 2	Total	Rounded
0.91	1.23		
8.764	7.63		
2.6	31.7		
937	40.01		
0.722	634.23		

Division Practice

Value 1	Value 2	Total	Rounded
5.3	748		
3781	6.50		
91×10^{2}	180		
5.56	22×10^{-3}		
3.142	8.314		

Means

Rule

- Remove anomalies
- Use remaining values
- Round to **least decimal places**

Practice

Value 1	Value 2	Value 3	Mean	Rounded
1	1	2		
435	299	437		
5.00	6.0	29.50		
5.038	4.925	4.900		

3. Converting Length, Area and Volume

Introduction

Whenever substituting quantities into an equation, you must always use **SI units**, such as:

- Time → seconds (s)
- Mass → kilograms (kg)
- Distance → metres (m)

If the question does not give quantities in the correct units, you should **always convert the units first**, rather than at the end.

Sometimes:

- Area may be given in **mm^2**
- Volume may be given in **cm^3**

These must be converted into **m^2** and **m^3 before using equations**.

Basic Length Conversions

$$1\ \text{m} = 100\ \text{cm} = 1000\ \text{mm}$$
$$1\ \text{cm} = 10\ \text{mm}$$

Conversion Table

Conversion	Operation	Conversion	Operation
m → cm	× 100	cm → m	÷ 100
m → mm	× 1000	mm → m	÷ 1000

✅ **Key Tip**

Always think:
"Should my number be getting larger or smaller?"
This helps decide whether to multiply or divide.

Converting Areas

A **1 m × 1 m square** is equivalent to a **100 cm × 100 cm square**

$$1\ \text{m}^2 = 10\ 000\ \text{cm}^2$$

Similarly:

$$1\ \text{m}^2 = 1\ 000\ 000\ \text{mm}^2$$

Area Conversion Table

Conversion	Operation	Conversion	Operation
m^2 → cm^2	× 10 000	cm^2 → m^2	÷ 10 000
m^2 → mm^2	× 1 000 000	mm^2 → m^2	÷ 1 000 000

Converting Volumes

A **1 m × 1 m × 1 m cube** =
a **100 cm × 100 cm × 100 cm cube**

$$1\ \mathrm{m}^3 = 1\ 000\ 000\ \mathrm{cm}^3$$

Similarly:

$$1\ \mathrm{m}^3 = 10^9\ \mathrm{mm}^3$$

Volume Conversion Table

Conversion	Operation	Conversion	Operation
$\mathrm{m}^3 \rightarrow \mathrm{cm}^3$	× 1 000 000	$\mathrm{cm}^3 \rightarrow \mathrm{m}^3$	÷ 1 000 000
$\mathrm{m}^3 \rightarrow \mathrm{mm}^3$	× 10^9	$\mathrm{mm}^3 \rightarrow \mathrm{m}^3$	÷ 10^9

Conversions Practice

Convert the following:

Given	=	Answer		Given	=	Answer
6 m^2	=	cm^2		750 mm^2	=	m^2
0.002 m^2	=	mm^2		5×10^{-4} cm^3	=	m^3
24 000 cm^2	=	m^2		8.3×10^{-6} m^3	=	mm^3
46 000 000 mm^3	=	m^3		3.5×10^{2} m^2	=	cm^2
0.56 m^3	=	cm^3		152 000 mm^2	=	m^2

Further Conversions

Use the same method as above:

Given	=	Answer
31×10^8 m^2	=	km^2
59 cm^2	=	mm^2
24 dm^3	=	cm^3
4500 mm^2	=	cm^2
5×10^{-4} km^3	=	m^3

Hint:

$$1 \text{ dm} = 10 \text{ cm}$$

Application Question

A solid copper cylinder has:

- Length = **2.0 m**
- Cross-sectional area = **3.0×10^2 mm^2**

Find its volume in cm^3

$$\text{Volume} = \_\_\_\_\_\_\_ \text{ cm}^3$$

Mixed Unit Conversions

For the following, decide whether the value should increase or decrease.

Example

Convert:

$$5 \text{ m ms}^{-1} \rightarrow \text{ m s}^{-1}$$

You travel **more metres in 1 second than 1 millisecond**, so:

$$5 \times 1000 = 5000 \text{ m s}^{-1}$$

Practice

Given	=	Answer
5 N cm^{-2}	=	N m^{-2}
1150 kg m^{-3}	=	g cm^{-3}
3.0 m s^{-1}	=	km h^{-1}

Given	=	Answer
65 kN cm^{-2}	=	N mm^{-2}
7.86 g cm^{-3}	=	kg m^{-3}

4. Rearranging Equations

Task

Rearrange each equation into the subject shown in the middle column.

Set 1

Equation	Subject	Rearranged Equation
$V = IR$	**R**	
$I = \dfrac{Q}{t}$	t	
$\rho = \dfrac{RA}{l}$	**A**	
$\varepsilon = V + Ir$	r	
$s = \dfrac{(u+v)}{2}t$	**u**	

Set 2

Equation	Subject	Rearranged Equation
$hf = \phi + E_K$	f	
$E_P = mgh$	g	
$E = \frac{1}{2}Fe$	F	
$v^2 = u^2 + 2as$	u	
$T = 2\pi\sqrt{\frac{m}{k}}$	m	

5. Variables

Definition

A variable is a quantity that takes part in an experiment.

Types of Variables

- **Independent variable** → the quantity you **change**
- **Dependent variable** → the quantity you **measure**
- **Control variables** → quantities you **keep the same**

You can only have:

- ONE independent variable
- ONE dependent variable
- MANY control variables

More control variables → **more reliable results**

Variable Types (Advanced)

- **Continuous variable**
  - Can take ANY value (including decimals)
  - Graph → **line graph**
- **Discrete variable**
  - Specific values/categories only
  - Graph → **bar chart**

Case Studies

Case Study 1 – Measuring the Effect of Gravity

The aim of this experiment is to find out how fast objects of different masses take to fall from height.

- Spheres of **same diameter**, different masses
- Mass measured using electronic scales
- Dropped from **2.000 m**
- Time measured using stopwatch
- Repeated **3 times**, then averaged

Independent variable: ______
Dependent variable: ______

Control variables: ______

Type of independent variable: ______
Graph: ______

Case Study 2 – After School Activities

The aim is to determine which activities are most popular.

- Number of children recorded
- Different activity types

Independent variable: ______
Dependent variable: ______
Control variables: ______

Type: ______
Graph: ______

Case Study 3 – Spring Stretch

The aim is to find how far different masses stretch a spring.

- Spring hung from clamp
- Length measured
- 10 g added each time (0–100 g)

Independent variable: ______
Dependent variable: ______
Control variables: ______

Type: ______
Graph: ______

Case Study 4 – Turbine Design

- Turbine placed 1.0 m from fan
- Volt output measured
- Number of blades changed

Independent variable: ______
Dependent variable: ______
Control variables: ______

Type: ______
Graph: ______

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6. Accuracy, Precision and Resolution

Definitions

- **Accuracy** → close to the true value
- **Precision** → results cluster together (repeatability)
- **Resolution** → smallest measurable change

Uncertainty

- Variation in measured data
- Usually ≈ resolution

Examples:

- Ruler → ±1 mm
- Stopwatch → ±0.2 s (reaction time)

Example Question

True temperature: **22.4°C**

Measurements:

- 22°C
- 23.4°C

→ Which is more accurate?
→ What is the uncertainty?

Practical Example

Measurements of insect mass:

- 5.00 mg
- 5.01 mg
- 4.98 mg
- 5.02 mg

True value = 4.5 mg

Task:

- Calculate mean
- Estimate uncertainty
- Compare with true value

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7. Identifying Errors

Types of Error

Random Errors

- Caused by environment / measurement variation
- Can be higher or lower than true value

✅ Reduced by:

- Repeating measurements
- Averaging
- Taking care

Systematic Errors

All results shift in one direction.

Types:

1. Zero Error

- Instrument doesn't start at zero

2. Parallax Error

- Reading at an angle

Key Point

Repeating measurements **does NOT fix systematic errors**

Anomalies

- Results far from other values
- Should be:
  - identified
  - repeated
  - excluded

Practice Table

Measurement	Source of Error	Type of Error	Improvement
Length of wire varies			
Current higher for one group			
Rebound height varies			

LDR graph differences			
Pendulum time varies			

Practical Skills Task

You are given the following equipment and asked to design a method to investigate the acceleration of free fall, *g*.

Equipment

- **ruler**
- **stopclock**
- **ping pong ball**

Write a method for this practical, including ways to increase the reliability of your measurements.

Using the relationship and the data below, plot a graph h against t^2 of and calculate g using the gradient. You will need to put the equation in terms of y=mx+c

$$g = 2h / t^2$$

Raw Data

Height (m)	Time 1 (s)	Time 2 (s)	Time 3 (s)
0.5	0.32	0.3	0.31
0.75	0.39	0.4	0.38
1.0	0.45	0.44	0.46
1.25	0.51	0.5	0.52
1.5	0.55	0.56	0.57

Processed Data

Height (m)	Mean time (s)	t^2 (s^2)
0.5		
0.75		
1.0		
1.25		
1.5		

11. Wider Reading Task

Read the article here "Bend it like dark matter"

https://iopscience.iop.org/article/10.1088/1361-6552/abe09c

Write a brief summary using the following prompts:

1. What did you already know about this topic?

2. What was the most interesting thing for you in this article?

3. If you could research one specific part of this article in more detail, what would it be? Explain your choice.

Answer Section

1. Prefixes and Units – Completed Answers

Conversions to Base Units

- 54 MN = 5.4×10^{7} N
- 0.086 μV = 8.6×10^{-8} V
- 753 GPa = 7.53×10^{11} Pa
- 23.87 mm/s = 2.387×10^{-2} m s^{-1}

Conversions to Prefixed Units

- 640 GV = 6.40×10^{11} V
- 0.5×10^{-6} A = 0.5 μA
- 93.09×10^{9} m = 93.09 Gm
- 32×10^{5} N = 3.2×10^{6} N = 3.2 MN
- 0.024×10^{-7} m = 2.4×10^{-9} m = 2.4 nm

Time Prefix Conversions

0.000000789 s:

- ms = 7.89×10^{-4}
- μs = 0.789
- ns = 789
- ps = 7.89×10^{5}

0.00000000064 s:

- ms = 6.4×10^{-7}
- μs = 6.4×10^{-4}
- ns = 0.64

- ps = 640

Length Conversions

1287360 mm:

- m = 1287.360
- km = 1.28736
- μm = 1.28736×10^{9}
- Mm = 1.28736×10^{-3}

295 mm:

- m = 0.295
- km = 2.95×10^{-4}
- μm = 2.95×10^{5}
- Mm = 2.95×10^{-7}

Wave Speed Calculations

1. $v = 1.4 \times 10^{5}$ m s^{-1}
2. $\lambda = 1.1 \times 10^{-4}$ m
3. $f = 6.0 \times 10^{15}$ Hz
4. $f = 5.0$ GHz

2. Significant Figures – Completed Answers

Sig Fig Table

Value	Sig Figs	Value	Sig Figs	Value	Sig Figs	Value	Sig Figs
2	1	1066	4	1800.45	6	0.070	2
2.0	2	82.42	4	2.483×10^4	4	69324.8	6
500	1	750000	2	0.0006	1	0.0063	2
0.136	3	310	2	5906.4291	8	9.81×10^4	3
0.0300	3	3.10×10^4	3	200000	1	40000.00	7
54.1	3	3.1×10^2	2	12.711	5	0.0004×10^4	1

Addition/Subtraction

1. 56.30 → 56.3
2. 7126.26 → 7126
3. 40.371 → 40.4
4. 10.5873 → 10.6

Multiplication

1. 1.1193 → 1.12
2. 66.87 → 66.9
3. 82.42 → 82
4. 37441 → 37400
5. 457.7 → 458

Division

1. 0.00708 → 0.0071
2. 581.7 → 582
3. $5.06 \times 10^2 \rightarrow 5.1 \times 10^2$
4. $2.53 \times 10^2 \rightarrow 2.5 \times 10^2$
5. 0.378 → 0.38

Means

1. 1.33 → 1
2. 390.3 → 390
3. 13.50 → 13.5
4. 4.954 → 4.95
5. 724.0 → 724
6. 0.00039 → 0.00039
7. 30.338 → 30.3

<u>3. Converting Length, Area & Volume – Completed Answers</u>

Conversions

- 6 m^2 = 60000 cm^2
- 0.002 m^2 = 2000 mm^2
- 24000 cm^2 = 2.4 m^2
- 46 000 000 mm^3 = 4.6×10^{-2} m^3
- 0.56 m^3 = 560000 cm^3
- 750 mm^2 = 7.5×10^{-4} m^2

- $5 \times 10^{-4}\ cm^3 = 5 \times 10^{-10}\ m^3$
- $8.3 \times 10^{-6}\ m^3 = 8.3 \times 10^{3}\ mm^3$
- $3.5 \times 10^{2}\ m^2 = 3.5 \times 10^{6}\ cm^2$
- $152000\ mm^2 = 0.152\ m^2$

Further Conversions

- $31 \times 10^{8}\ m^2 = 3100\ km^2$
- $59\ cm^2 = 5900\ mm^2$
- $24\ dm^3 = 24000\ cm^3$
- $4500\ mm^2 = 45\ cm^2$
- $5 \times 10^{-4}\ km^3 = 5 \times 10^{5}\ m^3$

Cylinder Volume

- Volume = $600\ cm^3$

Mixed Unit Conversions

- $5\ N\ cm^{-2} = 5 \times 10^{4}\ N\ m^{-2}$
- $1150\ kg\ m^{-3} = 1.15\ g\ cm^{-3}$
- $3.0\ m\ s^{-1} = 10.8\ km\ h^{-1}$
- $65\ kN\ cm^{-2} = 6.5 \times 10^{4}\ N\ mm^{-2}$
- $7.86\ g\ cm^{-3} = 7860\ kg\ m^{-3}$

<u>5. Variables – Completed Answers</u>

Case Study 1 – Falling Spheres

- IV: Mass

- DV: Time to fall
- Controls: Height, diameter, environment, stopwatch method
- Type: Continuous
- Graph: Line graph

Case Study 2 – After School Activities

- IV: Activity type
- DV: Number of children
- Controls: Day, time, school
- Type: Discrete
- Graph: Bar chart

Case Study 3 – Spring Stretch

- IV: Mass added
- DV: Extension
- Controls: Spring, temperature, measurement method
- Type: Continuous
- Graph: Line graph

Case Study 4 – Turbine Design

- IV: Number of blades
- DV: Voltage output
- Controls: Distance from fan, fan speed, turbine position
- Type: Discrete
- Graph: Bar chart

6. Accuracy, Precision, Resolution – Completed Notes

- Accuracy: Closeness to true value
- Precision: Repeatability
- Resolution: Smallest detectable change

7. Types of error

Length of wire varies – Random error – Repeat and average
Current higher for one group – Systematic error – Calibrate or replace ammeter
Rebound height varies – Random error – Repeat and average
LDR graph differences – Random error – Control lighting
Pendulum time varies – Random error – Use light gates or repeat and average