St Thomas More Catholic Academy
FAITH | EXCELLENCE | RESPECT

A level Physics
Y11 to 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!

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		

Tips on completing this bridging work

- Please write all of your answers clearly in **blue** or **black ink**.
- In calculations show all steps in your working clearly and underline the final answer.
- Where answers or a mark scheme is given mark and correct your work in **green pen**.

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. An A4 file
    b. pre-punched A4 paper for your notes
    c. plastic wallets for handouts
    d. pen, pencil, ruler (30cm is best), protractor, compasses
    e. Scientific calculator

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 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 practise, 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 x1,000,000. (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			× 1,000,000
k			× 1000
(None)	- - -	- - -	× 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:
   - g. 0.005 A =
   - h. 30000 s =
   - i. 5×10^{5} m =
   - j. 1001 m =
   - k. 0.006 V =
   - l. 2,100,000 N=
4. Convert each of the following to the indicated units:
   - a. 34 nm = ... mm
   - b. 0.012 s = ... µs
   - 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 = $\underline{m \cdot s^{-1}}$ (‘metres per second’)*

(c) The unit of charge = the unit of current × the unit of time = <u>A·s</u> (‘amp second’)

*NOTE: At A level we write divided units, such as ‘metres <u>per second</u>’ 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 though the defining equations one by one, unit 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 **$N = kg \cdot m \cdot s^{-2}$**)
- Therefore, a joule = **N m** = (**$kg \cdot m \cdot s^{-2}$**) **m** = **$\underline{kg \cdot m^2 \cdot s^{-2}}$**

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 ....

b) .00055 ....

c) 2.0002 ....

d) 120000 *(2sf)* ....

e) 120000 *(6sf)* ....

f) 843×10^4 ....

g) 1.5 µm ....

h) 12.0×10^{-2} 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.

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 (m^2) = 120 mm × 250 mm

b) Area (m^2) = 2.4 m × 60 cm

c) Density ($kg \cdot m^{-3}$) = 48 g ⁄ 12 cm^3

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

e) Speed squared, $v^2 = (16\ m \cdot s^{-1})^2$

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

5. RULES FOR SIGNIFICANT FIGURES (sig fig or sf)

Read from the left and start counting sig figs when you encounter the first non-zero digit

1. All non zero numbers are *significant* (meaning they count as sig figs)
   - 613 has three sig figs
   - 123456 has six sig figs
2. Zeros located between non-zero digits are *significant* (they count)
   - 5004 has four sig figs
   - 602 has three sig figs
   - 6000000000000002 has 16 sig figs!
3. Trailing zeros (those at the end) are *significant* only if the number contains a decimal point; otherwise they are insignificant (they **don't** count)
   - 5.640 has four sig figs
   - 120000. has six sig figs
   - 120000 has two sig figs – unless you're given additional information in the problem
4. Zeros to left of the first nonzero digit are *insignificant* (they **don't** count); they are only placeholders!
   - 0.000456 has three sig figs
   - 0.052 has two sig figs
   - 0.000000000000000000000000000000000052 also has two sig figs!

Rules for calculations

When you perform a calculation the answer should be given to the same number of significant figures as the weakest piece of data that was used in the calculation. For example if a piece of card is 11.3 cm long and 2.4 cm wide then the area = 27.12 cm^2 (on the calculator), but should be written as **27 cm^2** (i.e. 2 sig fig) because the width (2.4) was only given to 2 sig fig.

C. Practice Questions

1. State the number of sig figs in each of the following numbers:

(a) 0.0000055 g ……………… (c) 1.6402 g ……………… (b) 3.40×10^3 mL ………………

2. Compare the following numbers:

370 000 v 3.70×10^6 (standard form)

3. Explain the advantage of giving an answer in standard form

....

....

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) $\rho = m / V = 0.542$ g / 0.027 cm^3 = ……………………………………………$g{\cdot}cm^{-3}$

(b) $E = m c^2 = 231.5 \times 10^{-3} \times (3.00 \times 10^8)^2$ = ……………………………………………J

(c) Mean time = (23 + 20 + 21 + 22 + 25) / 5 = …………………………………………s

(d) Height difference = 2.32m – 2.07m = …………………………………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) $923\text{Kg} \times 9.8\ \text{m}\cdot\text{s}^{-2}$

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

7. SHOWING YOUR WORK 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.

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

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

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

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

8. 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 <u>check your answers</u>. 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 <u>will</u> improve. Importantly, have fun!

1. How many mm^2 are there in

   (a) $1cm^2$? ....

   (b) $1\ m^2$? ....

   (c) $1\ km^2$? ....

2. How many cm^3 are there in

   (a) $1mm^3$? ....

   (b) $1\ m^3$? ....

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 × 52 × 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 = ...c kg m^{-3}

c) Density = ...kg mm^{-3}

7. A regular block of metal has sides 12.2 × 3.7 × 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) 6.237×10^4 mm^2 (62,370 mm^2)
   b) 6.237×10^2 cm^2 (623.7 cm^2)
   c) 6.237×10^{-2} m^2 (0.06237 m^2)
4. 4420
5. 9.79×10^{19}
6. a) 1×10^{-3} kg cm^{-3}
   b) 1×10^6 kg m^{-3}
   c) 1×10^{-6} kg mm^{-3}
7. 2.50×10^3 kg m^{-3}
8. a) 3125 mm^2
   b) 63.1 mm
9. 2.0×10^{30} kg
10. 338 W m^{-3}