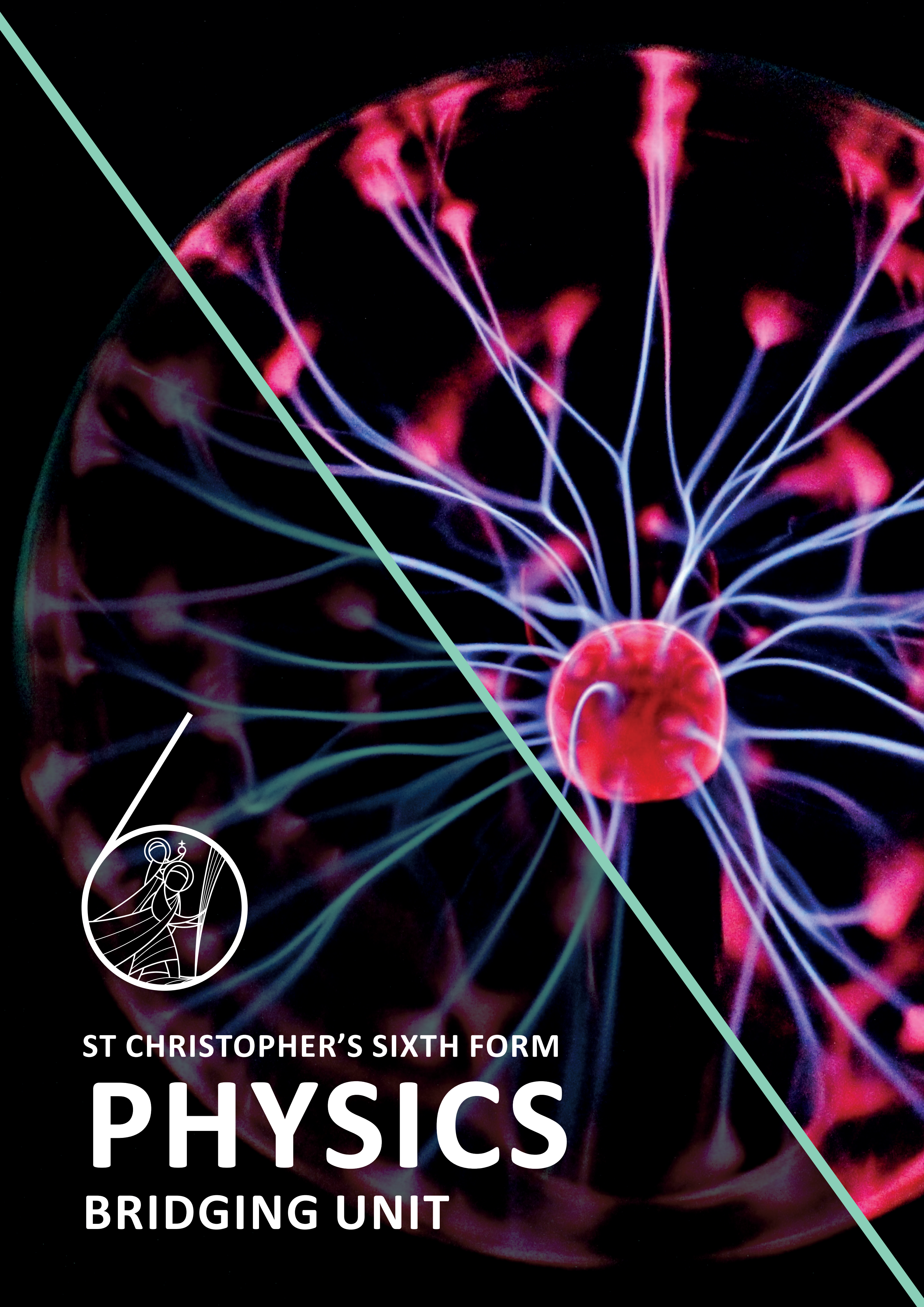

ST CHRISTOPHER'S SIXTH FORM

PHYSICS

BRIDGING UNIT

Physics

A-Level Physics Pre-Course Assignment

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"The important thing is not to stop questioning. Curiosity has its own reason for existing."

Albert Einstein

Be Curious

As a physicist you are be curious, you seek to explain the things around you, to find logic to the deepest mysteries, and enjoy discovering how and why things happen. A physicist enjoys solving problems with rules, maths and logic.

YouTube:
Educational channels, often for both GCSE and A-Level. Great for revisiting old topics and revising.

- **Science Shorts -** https://www.youtube.com/@ScienceShorts/playlists
  Great channel to that really goes into detail to explain many Maths and Physics principles
- **Physics Online -** https://www.youtube.com/@PhysicsOnline
  This is a very good and thorough, professionally created content.

YouTube:
Interesting channels that explore many Physics principles, taking classic ideas out of the classroom, and often taking you to the edge of modern theory.

- **Veratasium -** https://www.youtube.com/user/1veritasium
  Great channel to that really goes into detail to explain many Maths and Physics principles
- **Smarter every day -** https://www.youtube.com/user/destinws2
  Brilliant channel especially for engineering. Big builds, fun outcomes
- **Physics Girl -** https://www.youtube.com/results?search_query=physicsgirl
  Great Physics only channel. Tackles big physics and explains things you see every day.

Books – Good Scientific Reads:

- **Bill Bryson,** Short History of Nearly Everything
  Bryson is not a scientist, and his attempt to explain not just physics, but the whole world around us, is nothing short of a best-selling masterpiece
- **Stephen Hawking,** A Brief History of Time
  This was perhaps the original best-selling physics book. It's a little dated, but still very clearly explains so much about relativity and quantum physics, black holes and the Big Bang.
- **Brian Cox and Jeff Forshaw, Numerous titles**
  They have written several fantastic books explaining frontier Physics. To me, they take the mantle from Hawking for the 21st-century reader

The course we teach:

- **Specification**
  The course we teach is the AQA Physics A-Level specification (course code 7408 – pdf available online or by clicking here). During the two-year course, we build on the traditional branches of physics studied at GCSE, such as forces, motion, electricity and waves; and also goes into some new areas such as particle physics, quantum phenomena and gravitational fields.
- **Provision**
  At St Christopher's, the Science department has adopted the use of ***printed booklets***. These are tailored by the staff to complement both their teaching and the student's learning, and are reviewed and updated every year. They contain the content to be learnt, and specification links, retrieval practice, knowledge organisers, and lots of exam questions from previous years. Because these booklets replace the need for expensive textbooks, we ask for a small fee of £10 per year per student to help with the printing costs.

This Booklet

This bridging unit covers some of the basic skills and tools you will need. It does not shy away from the maths, because so often maths is often the language we use.

YOU MAY USE A CALCULATOR THROUGHOUT

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

Feedback:

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Physics

1. 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 <u>LEARN</u> 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 km = ...

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 = ... ʃs

c. 4.5 MJ = ... kJ

....

2. UNITS (a) The SI system of units

1. **Look up the following terms and write a few sentences about each:**

SI Units	
Base Units	
Derived Units	

2. **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)	

Physics
2. UNITS (b) Derived units

In physics all non-base quantities are called derived quantities and are defined by equations.
Eg. (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 = $\underline{A \cdot s}$** ('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 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 = $kg \cdot m2 \cdot s^{-2}$**

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 × ⌊)		

3. 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 [x10x] 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 (2*sf*)

....

e) 120000 (6*sf*)

....

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 (Λ) 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:

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

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 ∫s

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

....

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

....

Physics

4. 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
   - 0.0000000000000000000000000000000000052 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)

Explain the advantage of giving an answer in standard form

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3. **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) $E = m c^2 = 231.5 \times 10^{-3} \times (3.00 \times 108)^2$ = ………………………………………….J

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

(d) Height difference = 2.32m – 2.07m = ………………………………………….m

4. **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) $(12 \times 45g) / 12\ cm^3$

…………………………

d) $1.2 \times 10^{-6} \times 1.5 \times 10^{-4}$

…………………………

e) $(16\ m{\cdot}s^{-1})^2$

…………………………

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

…………………………

5. 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.** $R_1 = ?$

Physics

6. 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

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

7. 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 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) 1 mm^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) mm², (b) cm², (c) m². Give answers to the correct number of significant figures.**

a) Area = ... mm2

b) Area = ... cm2

c) Area = ... m2

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!)**

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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)**

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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.**

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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)

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9. **The diameter of the sun is 1.4 × 106 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)

....

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....

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?)

....

....

....

....

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 x10^4 mm^2 (62,370 mm^2)
   b) 6.237 x10^2 cm^2 (623.7 cm^2)
   c) 6.237 x10^{-2} m^2 (0.06237 m^2)
4. 4420
5. 9.79 x10^{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 × 103 kg m^{-3}
8. a) 3125 mm^2
   b) 63.1 mm
9. 2.0 x10^{30} kg
10. 338 W m^{-3}

Geometrical Equations

Arc length	=	rΘ
Circumference of circle	=	2π r
Area of circle	=	π r^2
Surface area of cylinder	=	2π rh
Volume of cylinder	=	π r^2h
Area of sphere	=	4π r^2
Volume of sphere	=	$\frac{4}{3}\pi$ r^3

KS4 Revision & Extension

8. Energy and Power

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

Work

....

....

Kinetic Energy

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Gravitational Energy

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....

Elastic Potential Energy

....

....

Efficiency

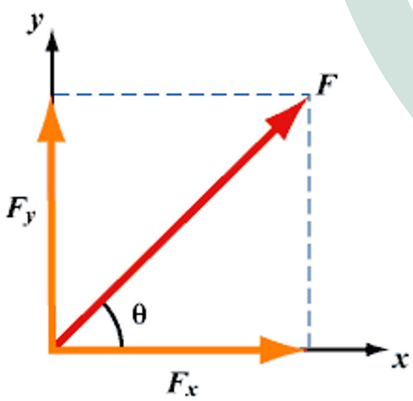
....

....

Power (including electrical power)

....

....



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.

Physics
Work

What is the definition of work?

....

....

.... (2)

In the following calculations take g = 9.8 N kg-1

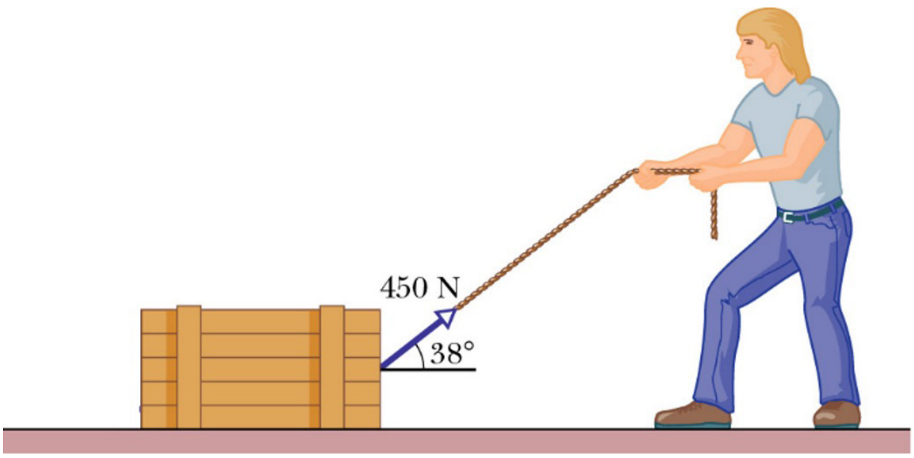
1) Calculate the work done in each of the following situations, stating the final form of the transferred energy.

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 Nm^{-1}. It extends by 14.0 cm.

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

Power

What is the definition of power?

....

....

.... (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

....

.... (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)

Physics
Speed

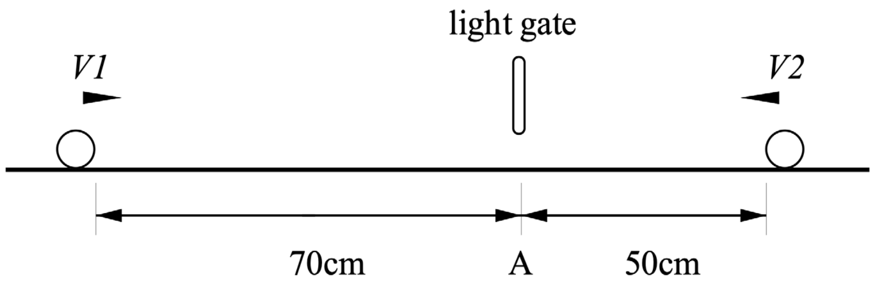
1. A bullet travels 300m in 2.60 seconds what is its velocity in (a) m s^{-1} (b) km h^{-1} ?

2. An alpha particle covers 2.0 cm travelling at 5% the speed of light (speed of light=3.0 x10^8 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 m s^{-1} and V2 = 0.20 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 × 10^8 m s^{-1}.

Acceleration

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?

....

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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}

....

....

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?

....

....

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

....

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"For I know the plans I have for you," declares the Lord,
"plans to prosper you and not to harm you,
plans to give you hope and a future."

Jeremiah 29:11

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