How to use this booklet

This booklet includes an introduction to the subject and any initial questions you may have about the course, such the content studied, the previous content needed, the university courses or careers the A-Level would lead to etc.

It also includes information about films, books and documentaries you could watch that would enhance and deepen your knowledge around the subject in the wider world.

Most importantly, each week there are three tasks set. Each week there will be at least one task that reviews some content or skills that is essential from GCSE which you should complete

A-level Physics Transition Work

Welcome to Physics!

Why choose to study Physics?

Studying Physics will provide you with essential analytical, mathematical and problem-solving skills. You will study all of the topics introduced at GCSE in more depth, with a greater focus on understanding why things happen and be introduced to new topics that you have not studied before, such as mechanics, particle physics and medical physics. You will have the opportunity to further develop your scientific skills from GCSE and use new pieces of equipment and apparatus.

If you enjoy learning about the world and questioning observations, then you will find this course rewarding, as you will learn to analyse situations and understand how and why situations occur. It is also an A-Level that is highly regarded by Universities and studying it will open up a wide range of opportunities and provide you with skills needed or highly sought after by many degree courses.

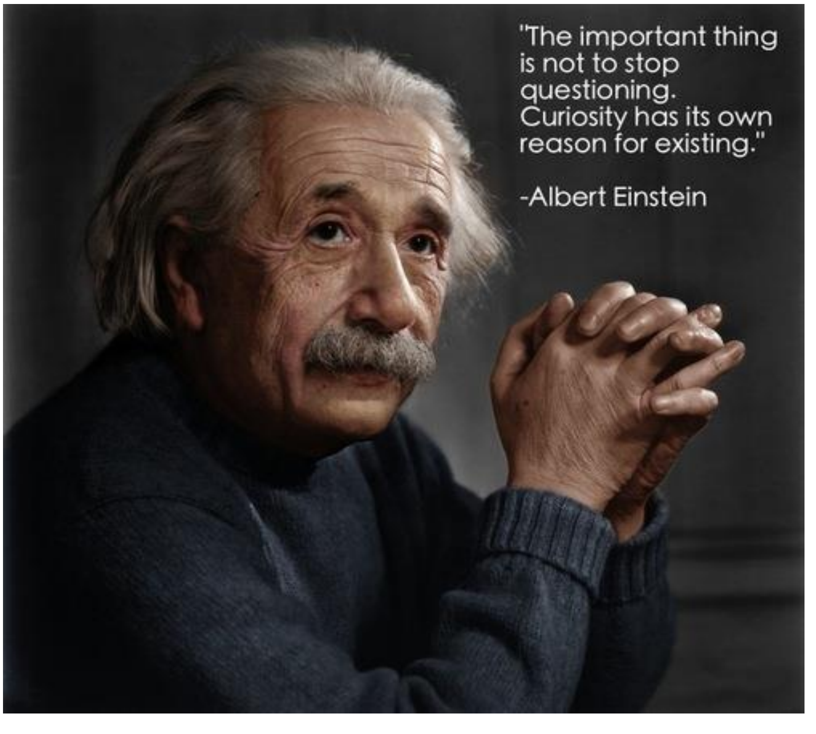
What can I do with my Physics A-Level?

Here are just some of the courses that require an A-Level in Physics:

- Natural Sciences
- Medicine
- Engineering
- Computer Science
- Radiography
- Teaching

Further courses students with A-Level Physics choose are: physiology, Law, nursing, midwifery, entomology, medical physics, forensic science, zoology, biology, botany, chemistry, astronomy, architecture, archaeology, etc

Physics is a challenging course and you will need to put in a considerable amount of time outside of lesson to ensure you have a concrete understanding of key concepts. However, the struggle is rewarding and enjoyable. The skills acquired from the course and that are honed over the 2 years are transferable into many disciplines and are highly regarded.



Welcome to Physics!

What knowledge and understanding do you need prior to studying AS and A-’Level Physics?

You will need to have achieved at least a grade 7 in Physics or Combined Science and also a grade 7 in Maths at GCSE. You will be secure in your knowledge of the fundamental aspects of Physics and should be confident with some basic mathematical concepts. These include:

- Rearranging equations and some basic trigonometry
- Electrical Circuits
- Forces and Motion (Forces, Momentum, Work done, Power)
- Waves and properties of waves including fundamental ideas about light

You will find it highly beneficial to review this material before starting the course as you will have a better grounding when introduced to more complex material.

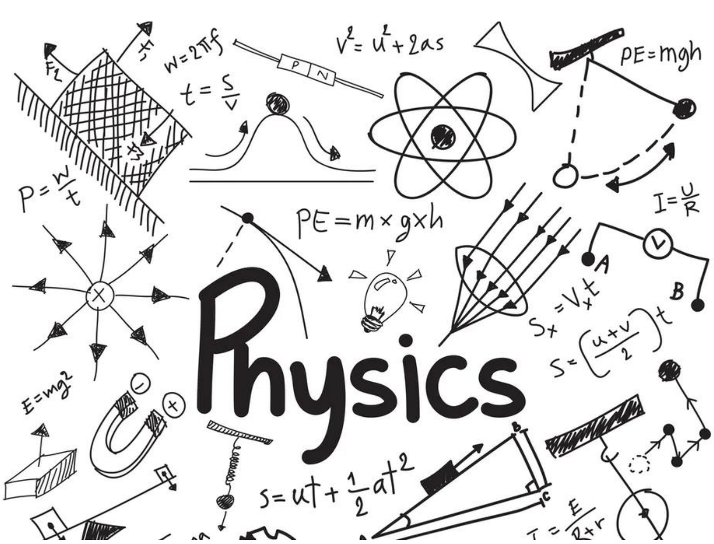
What will you study at AS and A-Level?

The course spans 2 years and covers a broad range of topics, some which you have visited before and some entirely new.

In Year 12, students study the mathematics required to understand the majority of the physics on the course. Students also study mechanics, which considers how objects behave when forces act on them and their subsequent motion. The other major topics in the course are Materials and their physical properties, Electrical Circuits, Waves and Wave experiments and Quantum Physics.

In Year 13, students study an additional course in mechanics which is more focussed on the motion of planets and the gravitational effects. Additional topics include Electrical Circuits, Medical Physics, Electric and Magnetic fields, Nuclear Physics, Particle Physics and Cosmology.

Over the course of the 2 years, students also carry out a range of practical experiments which enhance their understanding of the content taught in lessons. Students also undertake a minimum of 12 practical activities, which are assessed. These are compulsory and must be completed. Although they do not have any weighting towards your final grade, Universities will require a practical endorsement to show they have achieved the required competencies in practical work. Students also experiment with a wider range of equipment which they have not used before and have more freedom to develop their practical skills



Welcome to Physics!

Course details

Examination Board: OCR A

Specification name: Year 1 (AS) Physics – H156, Year 2 (A-level) Physics – H556

More information regarding the specification can be found at:

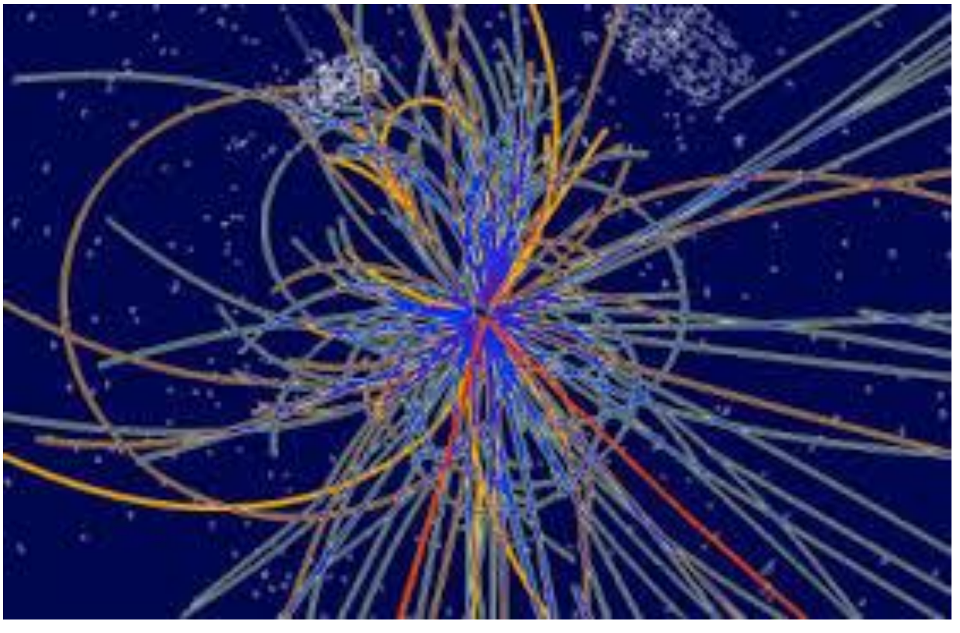
https://www.ocr.org.uk/qualifications/as-and-a-level/physics-a-h156-h556-from-2015/

The Specification at a glance

In the AS year, modules 2, 3 and 4 are taught, each covering a wide range of concepts and providing numerous opportunities to develop practical and problem-solving skills. Each module will also have required practicals associated to it that the exam board expects students to complete, to demonstrate an understanding of the real-life applications. This incorporates large elements of module 1.

In the A2 year, modules 5 and 6 are taught. Once again, students will develop practical skills through a range of practical work, which incorporates elements of module 1.

If exams are taken at the AS-Level (end of Year 12), all the content from the first year of study will be examined in both papers. If the course is taken to full completion for the full 2 years, the content will be assessed at the end of the course in year 13 via 3 exam papers. The first two papers cover specific modules, assessing key concepts, problem-solving ability in unfamiliar situations and the ability to apply knowledge in conjunction with mathematical skills. The final paper is a synoptic paper which assesses your ability to link different areas of physics together and to think logically when examining new and unfamiliar situations



Welcome to Physics!

Course details

Module 1 – Development of practical skills in physics

Skills of planning, implementing, analysis and evaluation

Module 2 – Foundations of Physics

Includes:
- Physical quantities and units
- Making measurements and analysing data
- Nature of quantities.

Module 3 – Forces and motion

Includes:
- Motion
- Forces in action
- Work, energy and power
- Materials
- Newton's laws of motion and momentum.

Module 4 – Electrons, waves and photons

Includes:
- Charge and current
- Energy, power and resistance
- Electrical circuits
- Waves
- Quantum physics.

Module 5 – Newtonian world and astrophysics (A level only)

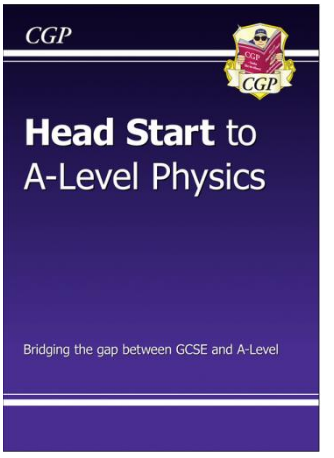
Includes:
- Thermal physics
- Circular motion
- Oscillations
- Gravitational fields
- Astrophysics.

Module 6 – Particles and medical physics (A level only)

Includes:
- Capacitors
- Electric fields
- Electromagnetism
- Nuclear and particle physics
- Medical imaging.

Welcome to Physics!

Preparatory work over the summer

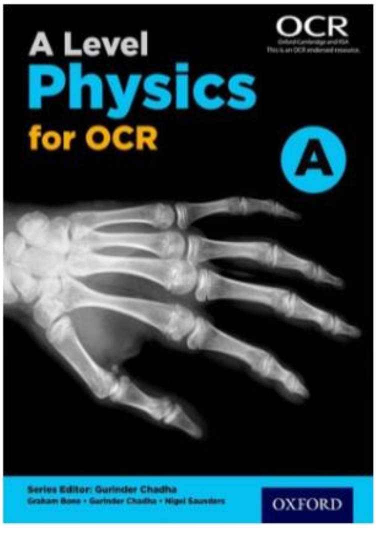


Students starting this course in September, will find it highly beneficial to review the GCSE material, especially that from P1 and P5 from the AQA Physics content. Other GCSE content is relevant but not for the start of the course. Teachers will give you further guidance on topics to review as they come closer to teaching it.

This bookIn addition to that students should complete the following CGP book, which reviews the essential GCSE content, to ensure students are well-equipped with the knowledge to bridge the gap between GCSE and A-Level. This should be completed for the first lesson back to school to ensure a good grounding.

Textbook for the course

The textbook below is OCR approved for the A-Level Physics course that is taught. We will expect you to use it in and out of lesson.



A Level Physics A for OCR Student Book
By Graham Bone

Week 1

Task 1: Fake News!

Does 5G cause coronavirus and how dangerous is it?

During the early days of the outbreak of Coronavirus, theories of its origin were emerging. One theory that was circulating linked Coronavirus to 5G telecommunications, with many telecom masts across the UK being targeted. Even before the outbreak, the question of whether ***5G is dangerous*** was being asked by multi media outlets and groups were forming on social media to petition against it.

When presented with information from the media, we need to be critical and most importantly check whether there is any accurate science underpinning their claims.

In this task, we will be using your knowledge from GCSE to explain why 5G is not dangerous.

a) Read the following article: https://www.bbc.co.uk/news/52168096

b) Read the following article: https://www.bbc.co.uk/news/world-europe-48616174

c) What are some of the ideas circulating that link coronavirus to 5G?

d) Answer the following questions:
   i. Which EM waves are the most energetic waves in the EM spectrum?
   ii. Which EM waves are least energetic waves in the EM spectrum?
   iii. What do we mean by '***ionising radiation'***?
   iv. Which EM waves are ionising and how might these affect our health?
   v. Which EM waves are not ionising? Do these have an impact on our health?

e) Using the articles, answer the following questions:
   i. Why does 5G not cause coronavirus?
   ii. Is 5G dangerous to our health and can it cause cancer? Use the idea of ionising radiation and high energy EM waves to explain your answer.

Week 1

Task 2: Would Spiderman's web actually hold his weight?

One of the best things about physics is that we can use it to answer some of our most bizarre questions about fictional worlds and hypotheticals.

Things we do not consider so much, is how accurate the physics in movies is. If we followed the laws of physics as we know them, would scenes in movies actually be possible.

So let's consider Spiderman. He uses spider silk as his webbing to swing from building to building, but could it actually withstand his weight? Would the tension in the silk rope cause it to snap?

Use the ***following sources as a starting point*** to research the properties of spider's silk, including its strength, elastic properties including Hooke's Law, to determine whether or not this would be viable.

Present your findings in a format of your choice – essay, powerpoint, video etc.

- https://www.youtube.com/watch?v=vzqBDW5k7Xk
- https://www.businessinsider.com/spider-man-far-from-home-silk-web-real-strong-realistic-2019-6?r=US&IR=T
- https://www.wired.com/story/spider-man-homecoming-web-physics/
- http://www.chm.bris.ac.uk/motm/spider/page2.htm

Week 1

Task 3: Essential Mathematical Skills – Part 1

At A level, unlike GCSE, you need to remember all symbols, units and prefixes.

Table 1 lists some of the quantities you will have come across with their units.

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.

Table 2 lists some common prefixes and the powers of ten that they refer to

Table 1

Quantity	Symbol	Unit
Velocity	v	ms^{-1}
Acceleration	a	ms^{-2}
Time	t	S
Force	F	N
Resistance	R	Ω
Potential difference	V	V
Current	I	A
Energy	E or W	J
Pressure	P	Pa
Momentum	p	$kgms^{-1}$
Power	P	W
Density	ρ	kgm^{-3}
Charge	Q	C

Table 2

Prefix	Symbol	Power of ten
Nano	n	$\times 10^{-9}$
Micro	µ	$\times 10^{-6}$
Milli	m	$\times 10^{-3}$
Centi	c	$\times 10^{-2}$
Kilo	k	$\times 10^{3}$
Mega	M	$\times 10^{6}$
Giga	G	$\times 10^{9}$

The table below shows you how to convert between prefixes, which is essential at A-level.

Symbol	Name	What it means		How to convert	
P	peta	10^{15}	1000000000000000		↓ x1000
T	tera	10^{12}	1000000000000	↑ ÷ 1000	↓ x1000
G	giga	10^{9}	1000000000	↑ ÷ 1000	↓ x1000
M	mega	10^{6}	1000000	↑ ÷ 1000	↓ x1000
k	kilo	10^{3}	1000	↑ ÷ 1000	↓ x1000
			1	↑ ÷ 1000	↓ x1000
m	milli	10^{-3}	0.001	↑ ÷ 1000	↓ x1000
µ	micro	10^{-6}	0.000001	↑ ÷ 1000	↓ x1000
n	nano	10^{-9}	0.000000001	↑ ÷ 1000	↓ x1000
p	pico	10^{-12}	0.000000000001	↑ ÷ 1000	↓ x1000
f	femto	10^{-15}	0.000000000000001	↑ ÷ 1000	

Week 1

Task 3: Essential Mathematical Skills – Part 1

Complete the table below with the correct prefixes and multipliers

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

Expand each of these quantities to write out the answer in full (e.g: 120mm = 0.12m)

a) 900mV =

b) 12MJ =

c) 1.67mm =

d) 3.456kg =

e) 700nm =

f) 0.72pA =

Write each of the following using an appropriate prefix:

g) 0.005A =

h) 30000s =

i) 5×10^5m =

j) 1001m =

k) 0.006V =

l) 2,100,000N =

Answer the following questions:

1. How many metres in 2.4 km?
2. How many joules in 8.1 MJ?
3. Convert 326 GW into W.
4. Convert 54 600 mm into m.
5. How many grams in 240 kg?
6. Convert 0.18 nm into m.
7. Convert 632 nm into m. Express in standard form.
8. Convert 1002 mV into V. Express in standard form.
9. How many m in 11 km? Express in standard form.
10. How many eV in 0.511 MeV? Express in standard form.

Convert each of the following to the indicated units:

a) 34nm = ...mm

b) 0.012s = ...µs

c) 4.5MJ = ...kJ

Week 1

Task 3: Essential Mathematical Skills – Part 1

At A level quantity will be written in standard form, and it is expected that your answers will be too.

This means answers should be written as ….x 10^y. E.g. for an answer of 1200kg we would write 1.2 x 10^3kg. For more information visit: www.bbc.co.uk/education/guides/zc2hsbk/revision

1. Write 2530 in standard form.
2. Write 280 in standard form.
3. Write 0.77 in standard form.
4. Write 0.0091 in standard form.
5. Write 1 872 000 in standard form.
6. Write 12.2 in standard form.
7. Write 2.4 x 10^2 as a normal number.
8. Write 3.505 x 10^1 as a normal number.
9. Write 8.31 x 10^6 as a normal number.
10. Write 6.002 x 10^2 as a normal number.
11. Write 1.5 x 10^{-4} as a normal number.
12. Write 4.3 x 10^3 as a normal number.

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

a) 3141	b) 0.00055	c) 2.0002
d) 120000	e) 45002	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

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

Example: calculate the resistance in ohms (Ω) for a current of 8.0 mA (milliamps) and a voltage of 12kV.

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

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 $m \cdot s^{-2}$

Week 1

Task 3: Essential Mathematical Skills – Part 1

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Week 1

Task 3: Essential Mathematical Skills – Part 1

At A level you will be expected to use an appropriate number of significant figures in your answers. The number of significant figures you should use is the same as the number of significant figures in the data you are given. You can never be more precise than the data you are given so if that is given to 3 significant your answer should be too. E.g. Distance = 8.24m, time = 1.23s therefore speed = 6.75m/s

The website below summarises the rules and how to round correctly.

http://www.purplemath.com/modules/rounding2.htm

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 <u>**27cm²**</u> (i.e. 2 sig fig) because the width (2.4) was only given to 2 sig fig.

Week 1

Task 3: Essential Mathematical Skills – Part 1

Give the following to 3 significant figures:

1. 3.4527
2. 40.691
3. 0.838991
4. 1.0247
5. 59.972

Practice Questions

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

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

For each value state how many significant figures it is stated to.

Value	Sig Figs	Value	Sig Figs	Value	Sig Figs	Value	Sig Figs
2		1066		1800.45		0.07	
2.0		82.42		2.483×10^4		69324.8	
2.00		750000		2.483		0.0063	
0.136		310		5906.4291		9.81×10^4	
0.34		3.10×10^2		200000		6717	

Add the values below then write the answer to the appropriate number of significant figures

Value 1	Value 2	Value 3	Total Value	Total to correct sig figs
51.4	1.67	3.23		
7146	−32.54	12.8		
20.8	18.72	0.851		
1.4693	10.18	−1.062		

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

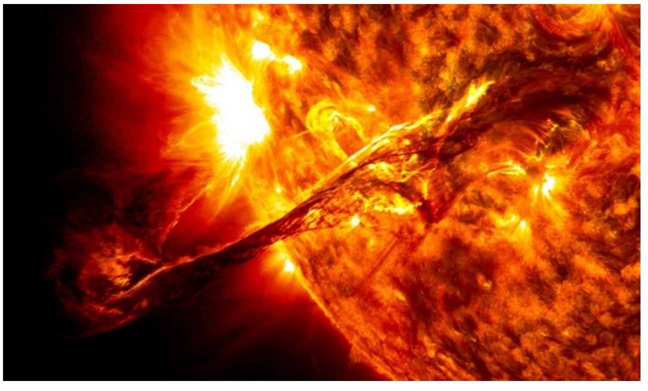
(d) Height difference = 2.32m – 2.07m = ……………………………….m

Week 2

Task 1: Are our satellites in danger?

Elon Musk, the CEO of SpaceX, is planning on launching 1500 satellites into his Starlink constellation in 2020, with the aim being that a total of at least 12000 will be launched over the duration of the Starlink project

Satellites are essential to our way of living – providing us with the ability to communicate, monitor weather, providing GPS for our phones and navigation systems, with governments and military using them for their own purposes.



Currently there are over 2000 artificial satellites in orbit around the Earth. However, there is a very real threat that all of communication systems could be made non-responsive, in a single event, which would lead to global catastrophes – the culprit, the Sun!

In this task you will be investigate the importance of monitoring the Sun's activity and also the growing problem of the increasing number of satellites in orbit around the Earth.

a) Watch the following video: https://www.youtube.com/watch?v=TCdgpY-qloI
   i. What is space weather?
   ii. How are the aurorae formed?
   iii. What is a coronal mass ejection (CME)?
   iv. How did the CME in 1859 affect the Earth?
   v. What would happen if a Carrington event were to happen today?
   vi. What happened in 2012?
   vii. What is special about sunspots?

b) Read the following article: https://earthsky.org/space/are-solar-storms-dangerous-to-us
   i. What is the difference between a solar flare and a CME?
   ii. Are solar storms dangerous to humans? Explain your answer
   iii. How might solar storms affect our technologies and what would be the impact?
   iv. What are scientists doing to help predict the next big event?

c) Read the following article: https://www.forbes.com/sites/startswithabang/2020/02/19/flaremageddon-how-satellite-mega-constellations-could-create-a-new-natural-disaster/#68fe6f8a49cf
   i. How many satellites have been launched into space in total?
   ii. What do you think happens to satellites when they outlive their purpose?
   iii. What is ***Kessler Syndrome?***
   iv. Describe the Sun's cycle.
   v. When is the next maximum due to occur?
   vi. What is the danger of space weather on a satellite? How might this affect other satellites?

d) Explain how the introduction of 12000 starlink satellites could put other satellites at risk.

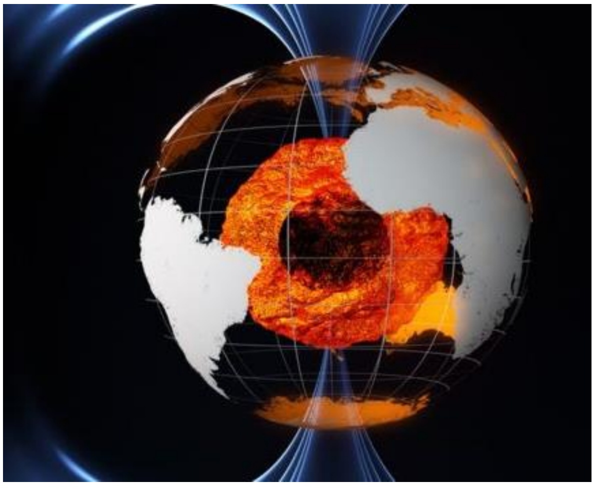
Week 2

Task 2: How often does the North Pole move?

The Earth's magnetic north pole is on the move. Over the past few years it has shifted from Canada and is moving towards Siberia, Russia.

What would this mean for our navigation systems that rely on the earth's magnetic field?

It is said that some animals use the Earth's magnetic field to migrate to new regions as temperatures change. How would this affect their seasonal migratory patterns?



Use the ***following sources as a starting point*** to research the how the Earth's magnetic field is created, how it shifts and wider implications

- https://www.bbc.co.uk/news/science-environment-52550973
- https://www.pbs.org/newshour/science/the-earths-magnetic-north-pole-is-shifting-rapidly-so-what-will-happen-to-the-northern-lights
- https://api.nationalgeographic.com/distribution/public/amp/news/2018/01/earth-magnetic-field-flip-north-south-poles-science
- https://www.businessinsider.com/earth-north-south-poles-flip-magnetic-field-2018-4?r=US&IR=T

Present your findings in a format of your choice – essay, powerpoint, video etc.

Include the following in your report:

- ✓ Name the 3 types of poles scientists use to describe the Earth and describe how each is different
- ✓ Describe how the earth's magnetic field is important to us and other animals
- ✓ Describe the science behind why it may be moving
- ✓ Explain the impact on earth of it moving
- ✓ Would it affect the position of the Aurora?
- ✓ What is geomagnetic reversal?

Week 2

Task 3: Essential Mathematical Skills – Part 2

Physics is beautiful because its key concepts can be simplified down to mathematical equations. These equations, when manipulated, can then unlock further insights.
It is imperative that we can manipulate equations and rearrange them fluently.

This is something you will have done at GCSE and it is crucial you master it for success at A level. For a recap of GCSE watch the following links:

- www.khanacademy.org/math/algebra/one-variable-linear-equations/old-school-equations/v/solving-for-a-variable
- www.youtube.com/watch?v=_WWgc3ABSj4

Rearrange the following:

1. E=m x g x h to find h
2. Q= I x t to find I
3. E = ½ m v^2 to find m
4. E = ½ m v^2 to find v
5. v = u + at to find u
6. v = u + at to find a
7. v^2 = u^2 +2as to find s
8. v^2 = u^2 +2as to find u

You will encounter many new equations in the Physics A-level. Some are below.

Rearrange the following.

1. $s = ut + \frac{1}{2}at^2$ Rearrange to find a) a b) u
2. $\lambda = \frac{h}{\sqrt{2meV}}$ Rearrange to find a) h b) m c) V
3. $E = \frac{m_0 c^2}{\sqrt{1 - \frac{v^2}{c^2}}}$ Rearrange to find a) m_0 b) v
4. $T = 2\pi\sqrt{\frac{l}{g}}$ Rearrange to find a) l b) g
5. $\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2}$ Rearrange to find a) R_T b) R_1 c) R_2

Week 2

Task 3: Essential Mathematical Skills – Part 2

This exercise brings together all the maths skills we have practiced so far.

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.

Lay out your working clearly, work step by step, and check your answers which are provided at the end.

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!

Questions:

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 the following units and give your answer in standard form
   a) mm^2
   b) cm^2
   c) 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 1mm3 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) $kg\ mm^{-3}$

7. A regular block of metal has sides 12.2 × 3.7 × 0.95 cm, and a mass of 107g. Find its density in kgm^{-3} to a suitable number of significant figures.

Week 2

Task 3: Essential Mathematical Skills – Part 2

Questions Continued….

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. Convert litres to cm^3 to simplify the problem first
   a) What is the area of the surface of the water (in mm^2)?
   b) What is the internal diameter of the cylinder (in mm)? TIP: Visualise the problem clearly. Draw a diagram if it helps. Use the equation of the volume of a cylinder)

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)

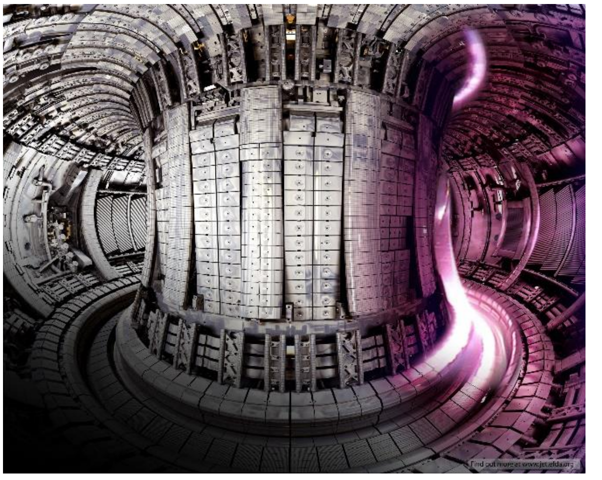
10. The total energy arriving in the Earth's upper atmosphere from the sun is 174 × 1015 Watts. Given that the Earth's diameter is 12.8 × 103 km, what is the average intensity of this radiation in Wm^{-2}? (TIP: Think about the units carefully. What does Wm^{-2} mean?)

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 × 10^3 kg m^{-3}
8. a) 3125 mm^2
   b) 63.1 mm
9. 2.0 x10^{30} kg
10. 338 W m^{-3}

Week 3

Task 1: How close are we to fusion?



Fusion is considered the Holy Grail of energy and is the process that powers our sun. Scientists have been working towards achieving fusion for decades. But how close are we to achieving it?

Well, the answer is… yes, it's done! Scientists have replicated the conditions for fusion on earth, the problem is sustaining and maintaining those conditions so that

China is one of the countries at the fore-front of this technology. In 2017, one of their nuclear fusion reactors, EAST (Experimental Advanced Superconducting Tokamak), was able to sustain certain conditions necessary for nuclear fusion for longer than 100 seconds. In 2018, it achieved hit a personal-best temperature of 100 million degrees Celsius – six times hotter than the Sun!

However this isn't the largest fusion reaction on Earth – an international collaboration has been constructing and building the largest TOKAMAK (plasma-fusion reactor) on Earth – ITER. The cost of the project – 20 billions euros!

a) Firstly we need to understand some basics: https://www.youtube.com/watch?v=mZsaaturR6E

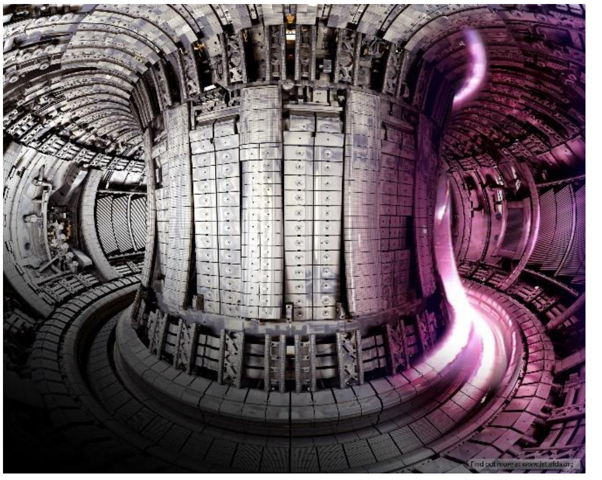
   i. What is a plasma?
   ii. Why would nuclei repel each other in a plasma and how is this repulsion overcome?
   iii. From GCSE, what is fusion?
   iv. How does a magnetic confinement reactor work? Give an example of a facility
   v. How does inertial confinement reactors work? Give an example of a facility
   vi. Why isn't fusion commercially viable yet?
   vii. What are the advantages of producing energy through fusion?
   viii. What problems do we encounter in obtaining raw materials?

b) The next video details, where we have got to so far in our journey to achieve fusion. Watch this video: https://www.youtube.com/watch?v=KlxPJ6LnyFc

   i. What are 3 conditions needed for fusion?
   ii. What is one of the problems we need to overcome?
   iii. What does a charged particle do in a magnetic field?
   iv. What is the shape is the magnetic trap in a tokamak?
   v. Name some countries where we have tokamaks.
   vi. What is break-even, and when and where did we achieve this?
   vii. What does ITER hope to do?
   viii. Where would the raw material for fusion come from?

Week 3

Task 1: How close are we to fusion?



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However this isn't the largest fusion reaction on Earth – an international collaboration has been constructing and building the largest TOKAMAK (plasma-fusion reactor) on Earth – ITER. The cost of the project – 20 billions euros!

c) Read the following articles below.

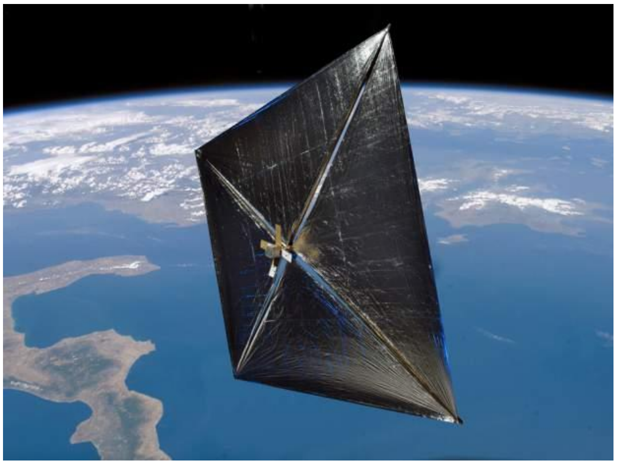
- https://blog.sciencemuseum.org.uk/could-nuclear-fusion-be-closer-than-we-think/
- https://phys.org/news/2019-04-china-quest-limitless-energy.html
- https://www.technologynetworks.com/analysis/articles/how-close-are-we-to-commercial-fusion-generators-334028
- https://www.ft.com/content/a8d0a7e4-20e3-11ea-b8a1-584213ee7b2b

Write a report that outlines the following:

- What is fusion?
- The reasons the scientific community are pursuing fusion and its importance in terms of global energy consumption
- Describe simply how tokamaks work and describe the current experimental projects and achievements to date
- Describe the main barriers to fusion

Week 3

Task 2: Sailing through space



Space exploration could never be more exciting. With all the technological advances made in the past decades to enhance telescopes and to analyse atmospheres and landscapes, we can gather information about distant celestial bodies with more precision.

But how close are we to actually travelling there?

The biggest problem is fuel – the fuel needed to get to these objects is massive. The higher the payload of the spacecraft, the more fuel is needed provide any force.

One answer may be found in solar sails.

These are extremely light thin sheets which act very much like a sail on a ship.

They will allow the instrument it carries to travel large distances, theoretically!

The power source – the Sun!

You are going to research how a solar sail works and how it may be used in the future.

The following page shows a diagram of the short history of solar sails.

Use the following sites as a starting point:

- https://www.planetary.org/explore/projects/lightsail-solar-sailing/what-is-solar-sailing.html
- https://www.newscientist.com/article/2211001-lightsail-2-unfurls-solar-sail-and-begins-travelling-through-space/
- https://www.youtube.com/watch?v=-ZDSvnzpRNI

Present your findings in a format of your choice – essay, powerpoint, video etc.

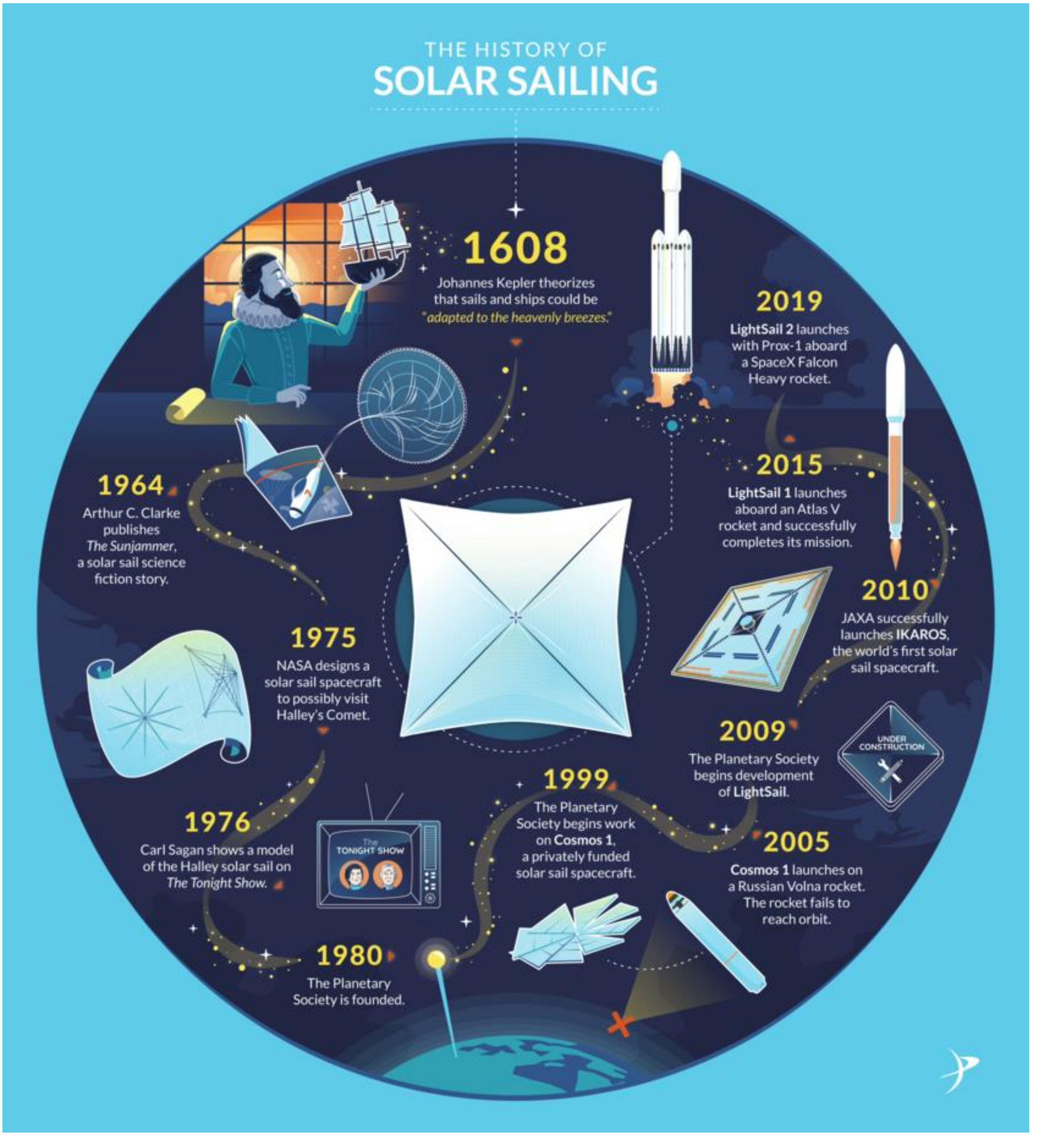
Include the following in your report:

- ✓ What is a solar sail and describe the sheet?
- ✓ Describe how a solar sail works.
- ✓ Give some details about the history of the physics of solar sail
- ✓ What is Lightsail 2 and what is its goal? What is its future?
- ✓ How might we use solar sails in the future?

Week 3

Task 2: Sailing through space

The diagram below shows a history of solar sails, from their conception to their implementation

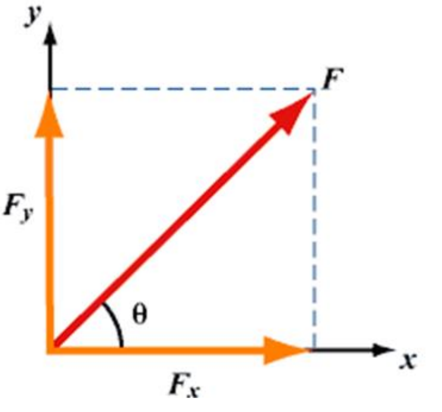


Week 3

Task 3: Essential Mathematical Skills – Part 3

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: a ***force F*** acts at an angle Θ. It can be treated as two individual forces - one acting horizontally (F_x) and another acting vertically (F_y).



At GCSE you did this through scale drawings:

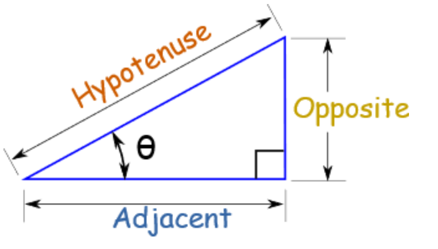
https://www.youtube.com/watch?v=8RI2_gJy0L0

We can also solve this with trigonometry. Trigonometry is a huge part of A Level Physics, but its becomes easy after plenty of practice. Lets practice so that we have the basics.

Watch the videos below:

- https://www.youtube.com/watch?v=q9ILOIyPmC8
- https://www.youtube.com/watch?v=z925v3v9Va4
- https://www.youtube.com/watch?v=fMkctIXg8P0

Finding angle using arc sin and arc cosine: https://www.youtube.com/watch?v=RWyY3n9nTf8



At A-level these components can be calculated with trigonometry:

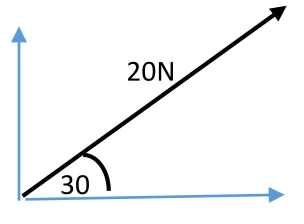
F_y = F sin (Θ) *and* **F_x= F cos (Θ)**

You may need to use this in the following questions

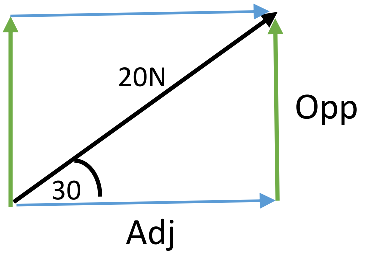
Watch the following video from Physics Online: https://www.youtube.com/watch?v=2kHCvtTjOJs

Worked example: A force of 20N at 30° to the horizontal. Resolve the force into its components.

Step 1: Draw out the diagram



Step 2: Label the opposite and adjacent



Step 3: To calculate the ***opposite*** you will use sine: sin(30) x 20 = ***10N***

Step 4: To calculate the ***adjacent*** you will use cosine: cos(30) x 20 = ***17.3N***

Week 3

Task 3: Essential Mathematical Skills – Part 3

Practice Questions

For the following scenarios, resolve the vector quantity into its horizontal and vertical components

a) A force of 40N at 35° to the horizontal

b) A force of 600N at 40° to the horizontal

c) A velocity of 30ms^{-1} at 25° to the horizontal

d) A velocity of 2000ms^{-1} at 60° to the horizontal

e) A force of 80N at 75° to the horizontal

For the following be careful about the location of the angle. Resolve into the horizontal and vertical components.

a) A velocity of 55ms^{-1} at 25° to the vertical

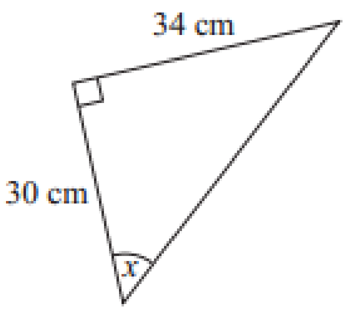
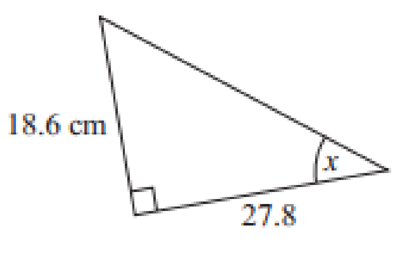
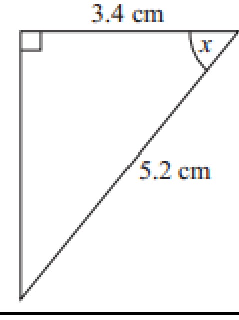
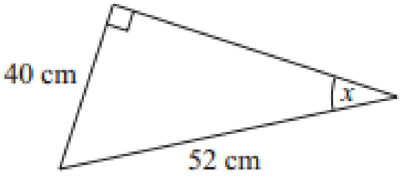
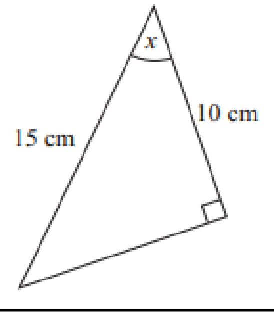
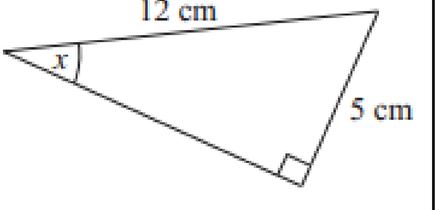
b) A velocity of 2000ms^{-1} at 40° to the vertical

c) A force of 80N at 35° to the vertical

d) A force of 38N at 15° to the vertical

e) A force of 2.5kN at 50° to the vertical

Using trigonometry, determine the angle in each of the triangles shown

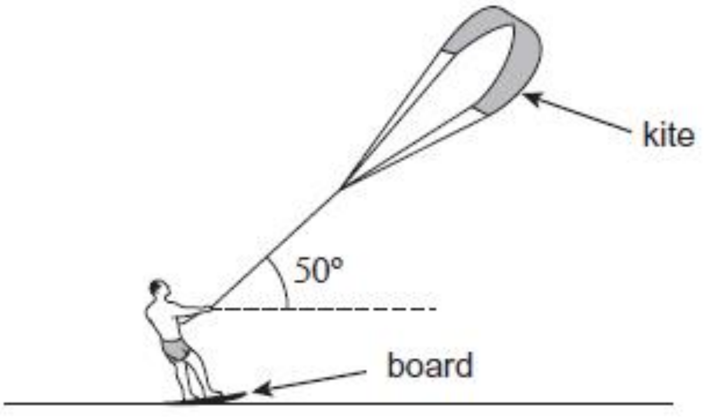
		
		

Week 3

Task 3: Essential Mathematical Skills – Part 3

Let's put your skills to the test with some A-level exam questions

Q1. Figure 1 shows a kite boarder holding a line that is attached to a kite.



The wind blows the kite and the kite boarder moves at a constant speed across a level water surface. The tension in the line is 720 N and the line makes an angle of 50° to the horizontal.

Calculate the ***vertical component of the tension*** in the line.

vertical component of tension ____________________ N **(2)**

Week 3

Task 3: Essential Mathematical Skills – Part 3

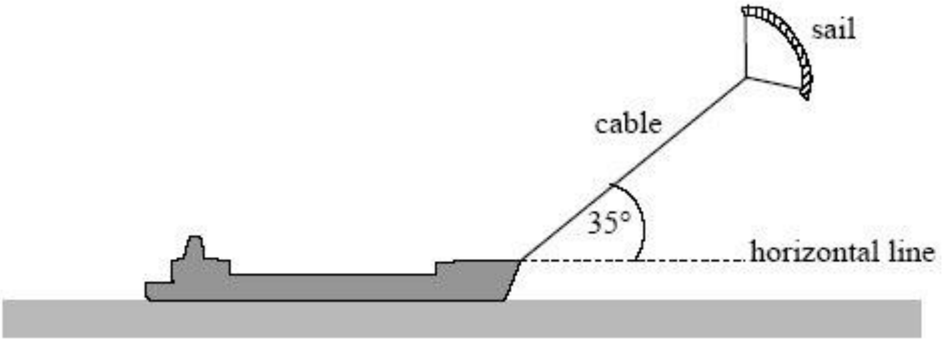
Let's put your skills to the test with some A-level exam questions

Q2. Answer the following

a) State the difference between a scalar quantity and a vector quantity. (1)

b) State **two** examples of a scalar quantity and **two** examples of a vector quantity (2)

Q3. The diagram below shows a ship fitted with a sail attached to a cable. The force of the wind on the sail assists the driving force of the ship's propellers.



The cable exerts a steady force of 2.8 kN on the ship at an angle of 35° above a horizontal line.

a) Calculate the ***vertical component of the force*** in the line.

vertical component of tension ____________________ kN **(1)**

b) Calculate the ***horizontal component of the force*** in the line.

horizontal component of tension ____________________ kN (1)

Week 4

Task 1: What happens to urine and faeces in space?

It's not a question you have probably considered, but for astronauts who make their journey into space and for those who live on the International Space Station (ISS), this is crucial. Without gravity, urine and faeces wouldn't actually remain in the toilet and would move freely, without confinement.

Throughout our history of human space exploration, space agencies, such as NASA, have had to invest and design technologies to solve the issue of human waste confinement. Currently 80% of urine can be recycled to provide drinking water for the astronauts

As much as we would like to think that the technology was sophisticated, unfortunately the reality is very different. For the Apollo missions of the 60s and 70s, there were no space toilets.

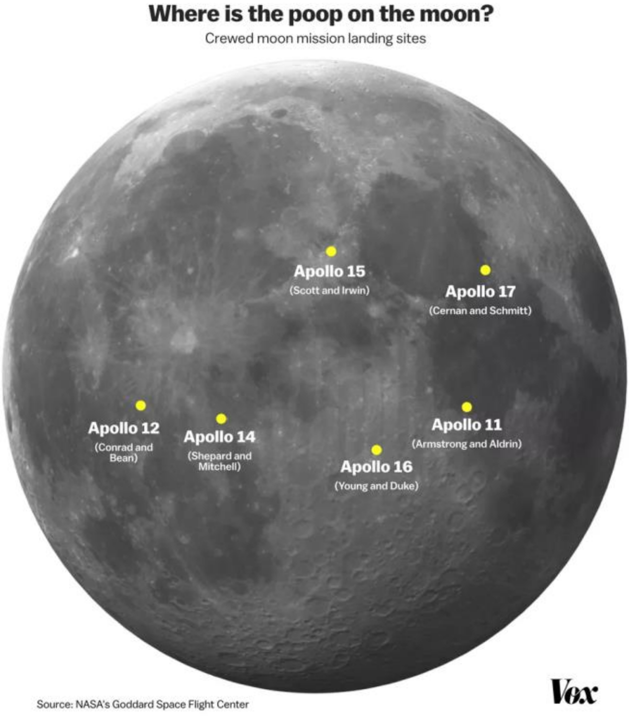
a) Briefly outline what the containment systems were like in the 60s.
https://www.businessinsider.com/bathroom-toilet-on-apollo-moon-missions-2019-7?r=US&IR=T

b) Read the article and produce a timeline of the different technologies to confine urine and faeces. Give a brief description of how each one works.
https://www.businessinsider.com/how-nasa-astronauts-pee-and-poop-in-space-2018-8?r=US&IR=T?utm_source=copy-link&utm_medium=referral&utm_content=topbar

c) During our early space missions, astronauts left their human waste on the Moon. There are over 90 bags of human waste on the moon, leftover from those early missions to the moon. One of the concerns is that we have now left bacteria on the moon. The bigger question is, is the bacteria still alive?

Read the information on the following page.

Summarise the following:
- What questions do scientists have that they are trying to answer?
- Why is the moon not hospitable to life?
- What is an extremophile?
- What does it mean if bacteria are 'revivable'?
- Where have we encountered dormant bacteria?
- How would this research help us understand the question to whether there was life on Mars?



What else did we leave on the moon?: https://www.youtube.com/watch?v=CZMO9Ud0tOU

It's been nearly 50 years since the Apollo 11 moon landing. Neil Armstrong's iconic footprint is still there, undisturbed; there's no atmosphere, no wind on the moon to blow it away. But the bigger human footprint on the moon is, arguably, the 96 bags of human waste left behind by the six Apollo missions that landed there. The human waste consists of faeces, urine, vomit, food waste and also microbes.

Human faeces are teeming with life. Around 50 percent of their mass is made up of bacteria, representing some of the 1,000-plus species of microbes that live in your gut. Planet Earth has hosted this life and so much more for upward of 3.9 billion years. The moon, as far as we know, has been sterile and lifeless that whole time.

With the Apollo 11 moon landing, we took microbial life on Earth to the most extreme environment it has ever been in. The bags have lingered there, and no one knows what has become of them. Now scientists want to answer a question that has profound implications for our future explorations of Mars: ***Is anything alive in them?***

"The moon missions were engineered very carefully, and weight was a very big issue," says Andrew Schuerger, a University of Florida space life scientist. "So it made sense if you're picking up moon rocks, you'd also want to discard things that were not necessary to increase your margin of safety."

The question scientists are asking may lead to important insights about the extreme conditions life can endure: How resilient is life on the environment of the moon? If microbes can survive on the moon, can they survive interstellar travel, making them capable of seeding life across the universe, including on places like Mars?

In all the ways Earth is hospitable to life, the moon is not. It does not have a protective magnetic field to deflect the most powerful and damaging cosmic radiation. It does not have an ozone layer to absorb the sun's ultraviolet rays. The vacuum of the moon is inhospitable to life. And without an atmosphere, the moon is subjected to huge changes in temperature from -173°C at night to 100°C during the day.

The surface conditions are harsh, but on Earth bacteria have survived some of the most extreme environments such as at the very bottom of the ocean, near scorching thermal vents, 2 miles beneath one of Greenland's glaciers. So bacteria may have survived…

Scientists say that the bags are worth studying, regardless of if there is life or not. They could possibly figure out how long the microbes lived on the moon and whether they evolved or adapted to the environment at all. There's a tiny chance that natural selection may have taken place, leading to the microorganisms evolving to survive. If there were just a few microorganisms in the poop with the ability to survive the moon, they could have grown and spread.

Again, this is the most extreme place we've ever left life — possibly the most extreme place life has ever been. We need to see how resilient (or not) it is in that environment. There's also the possibility that some microbes might be revivable - after decades of dormancy on the moon, some of these microbes might be able to be coaxed back to life under the right conditions. Bacterial spores (dormant bacteria that form a protective outer coating) in the Arctic have been revived after thousands of years frozen in ice. It would be fascinating if spores in faecal matter could be revived after decades on the moon.

If microbial life can survive on the moon, even in a dormant state, it could mean that microbes can survive long stretches of time in the deep reaches of space, traveling between worlds, propagating life along the way. And if microbes can survive for a given period on the moon, they're even more likely to survive on Mars, which has a thin atmosphere, a more hospitable environment.

Adapted from: https://www.vox.com/science-and-health/2019/3/22/18236125/apollo-moon-poop-mars-science

Week 4

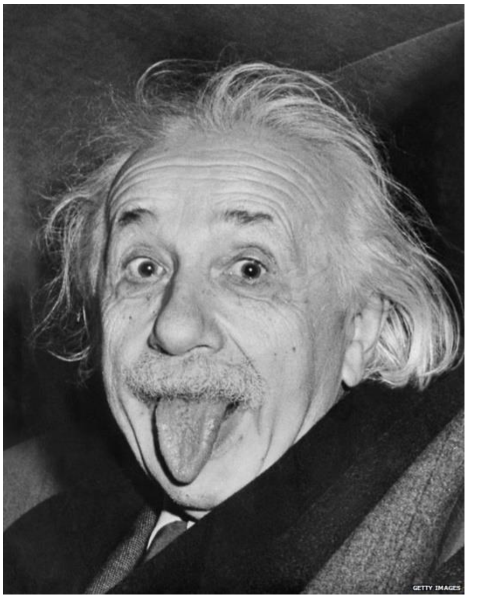
Task 2: Famous Physicists

Physics is ever evolving, with new theories constantly being updated, adapted, discarded or introduced.

The physicists who do this often spend decades researching and theorising, making it their life's work to see their work bear some fruit.

Albert Einstein is by far one of the most renowned faces in the world and one of the, if not the most, famous scientist.

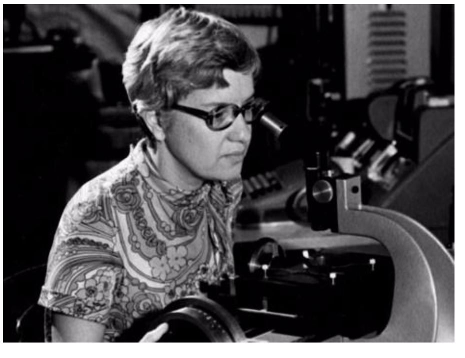
But how many people can tell you why he is so famous and what his research was about?



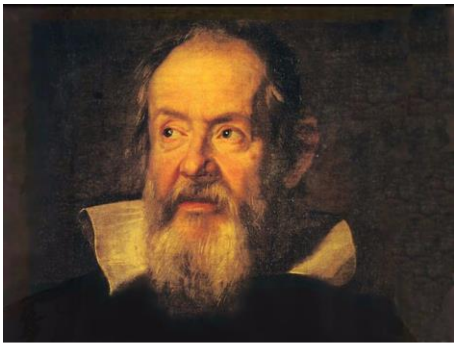
In this task you will research two physicists. You should describe their life and some of their most famous work. You should then describe if you can why their work was so important to the scientific community.

Here are some names to get you started:

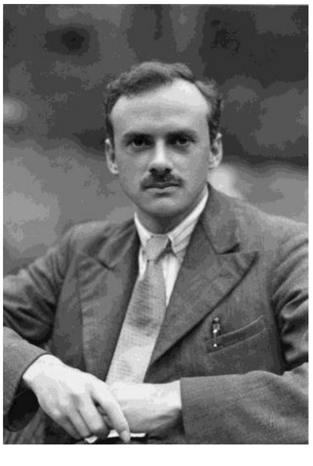
Lise Meitner



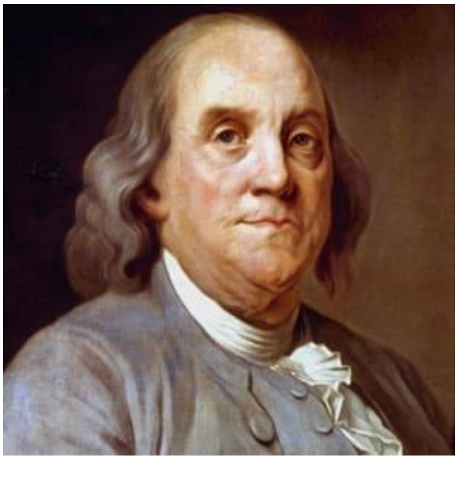
Vera Rubin



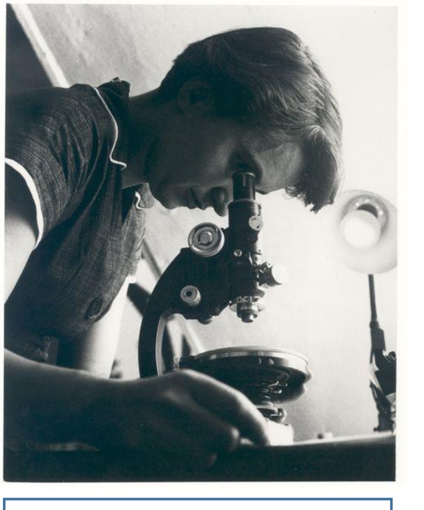
Galileo Galilei



Paul Dirac



Benjamin Franklin



Rosalind Franklin

Week 4

Task 3: Essential Mathematical Skills – Part 3

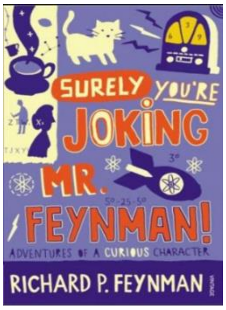
So much of physics requires us to understand the motion of objects.

The following tasks are to check you are able to calculate speed and acceleration

You will need to use your SUVAT equations to complete them.

1. A bullet travels 300m in 2.60 seconds what is its velocity in (a) ms^{-1} (b) kmh^{-1} ?
2. An alpha particle covers 2.0 cm travelling at 5% the speed of light (speed of light=3.0 x10^8 ms^{-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. 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 ms^{-1}.
5. A horse is cantering at 3.1 m s^{-1} and breaks into a gallop reaching a speed of 5.6 ms^{-1} in 3.5 seconds. Calculate its acceleration.
6. A car travelling at 16.0 m s^{-1}, brakes for 3.20 s, decelerating at a rate of 3.125 ms^{-2}. What is its final speed?
7. An Olympic diver strikes the water at a speed of 7.2 ms^{-1}, and comes to rest in 1.2 seconds. What is his acceleration?
8. A falling ball strikes a floor with a velocity of 4.2 ms^{-1} and rebounds with a velocity of -3.8ms^{-1}. It is in contact with the floor for 0.12 seconds. What was its acceleration?
9. 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}
10. 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 ms^{-1}. A moment later it passes the ground floor windows of the engineering faculty and an alert engineer records its speed as 12.91 ms^{-1}.
    a) Assuming acceleration due to gravity to be 9.81 ms^{-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.

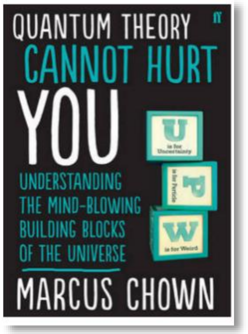
Book Recommendations

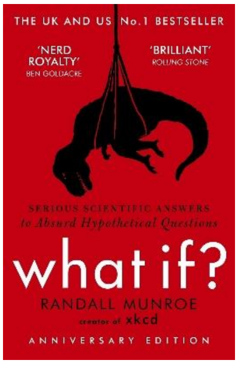


Richard Feynman was a Nobel Prize winning Physicist. In my opinion he epitomises what a Physicist is. By reading this book you will get insight into his life's work including the creation of the first atomic bomb and his bongo playing adventures and his work in the field of particle physics.

Any Physics book by Marcus Chown is an excellent insight into some of the more exotic areas of Physics that require no prior knowledge. In your first year of A-Level study you will meet the quantum world for the first time.

Really well written, and a great introduction to the weird and wonderful realm of quantum physics

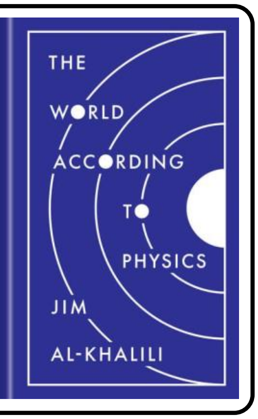


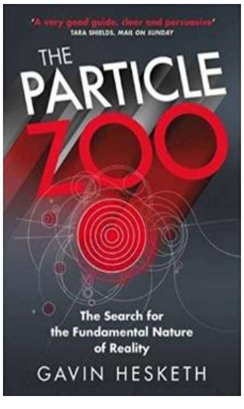


Hilarious and informative answers to important questions you probably never thought to ask such as when will Facebook contain more profiles of dead people than living?
Unputdownable!

Ever wanted to get into quantum physics, but been afraid to try? This book might be the answer. Al-Khalili makes cutting-edge physics understandable and shows how us why physics matters to everyone.

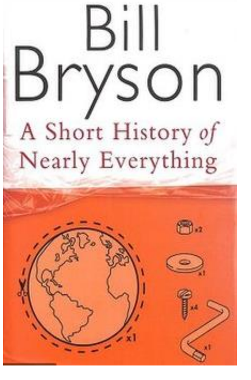
A must read for all physics lovers!

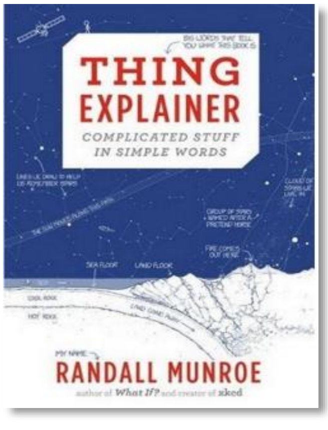




What is everything really made of? If we split matter down into smaller and infinitesimally smaller pieces, where do we arrive? At the Particle Zoo - the extraordinary subatomic world of antimatter, ghostly neutrinos, strange-flavoured quarks and time-travelling electrons and so much more!

A whistle-stop tour through many aspects of history from the Big Bang to now. This is a really accessible read that will re-familiarise you with common concepts and introduce you to some of the more colourful characters from the history of science!





A book of illustrated cartoon diagrams that should appeal to the scientific side of everyone. Written by the creator of online comic XTCD (a great source of science humour) is a book of blueprints from everyday objects such as a biro to the Saturn V rocket and an atom bomb, each one meticulously explained BUT only with the most common 1000 words in the English Language.

Dip in and out as you please! Excellent daytime, bedtime, thing-time reading!

Documentary and Movie Recommendations

The hunt is on! Physicists have been working for decades to find the elusive 'God Particle' – the Higg's particle.
This movie documents the pain-staking journey the physicists undertook to find a particle that would help them build a theory – a theory that would be able to combine all physics!

One of my all time favourites!

https://www.youtube.com/watch?v=akCJc7K3DUU

Professor Brian Cox tells the extraordinary life story of the solar system. For four and a half billion years each of the planets has been on an incredible journey, filled with astonishing spectacle and great drama. This series uses the data from the very latest explorations of the solar system to reveals the unimaginable beauty and grandeur of eight planets.

Available on iPlayer: https://www.bbc.co.uk/iplayer/episodes/p07922lr/the-planets

Jim Al-Khalili goes into the physics of what everything we see is made of and how it works. More interestingly he looks at 'nothing' – what is nothing? Does nothing always exist or does it fluctuate. This documentary breaks the physics down to its bare bones – riveting!

https://www.youtube.com/watch?v=gXbIzc3bcT8
https://www.youtube.com/watch?v=rKPv8zApee0

Ted-Ed: Does time exist?
The earliest time measurements were observations of cycles of the natural world, using patterns of changes from day to night and season to season to build calendars. More precise time-keeping eventually came along to put time in more convenient boxes. But what exactly are we measuring?

https://www.youtube.com/watch?v=R3tbVHlsKhs

There are also entire YouTube channels other websites dedicated to uploading documentaries. A couple are below

- Cosmos with Neil deGrasse Tyson: https://archive.org/details/Cosmos.A.SpaceTime.Odyssey.S01.720p.BluRay.x264/
- Reel Truth Science Documentaries: https://www.youtube.com/channel/UCZSE95RmyMUgJWmfra9Yx1A
- World Science Festival: https://www.youtube.com/user/worldsciencefestival

YouTube Channels and Podcasts

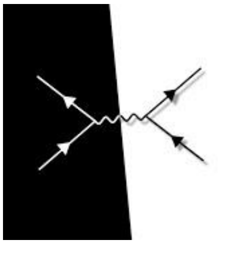
Podcasts: There are many science podcasts out there, which often discuss physics but nonetheless all the science is very amusing, enjoyable and insightful!

YouTube Channels: There is such a large range of YouTube channels that are dedicated to clarifying physics – from the physics that helps you along with the course to those that just answer your everyday physics questions.

Minute Physics

Gorilla Physics

Royal Institute



Physics Online

Veritasium

Kurzgesagt – In a Nutshell