Welcome to

A Level Physics

When you arrive in September you will need to bring:

- This document completed – either printed or saved to USB
- 2 x ring-binder folders with dividers
- Pens, pencils, ruler, rubber, protractor
- A scientific calculator. The standard CASIO one is recommended.

Note: although this booklet looks extensive, much of it is information rather than tasks

We estimate the tasks will take you around 3 hours to complete depending on how much you remember from GCSE physics (this time does not include reading a book).

The book review will be due after the October half term holiday. All other tasks are due in the first lesson.

Task list

Tasks	**Tick when complete**	**Pages**
Complete self-reflection of attitude towards learning		3-4
Choose one book from the reading list and read it		5-6
Write 250 words about what you have **found most interesting** about the book		6
Watch videos/look at websites related to physics	*optional*	*7*
Complete questions on fundamentals of physics		8-14
Set up an Isaac Physics Account and join the Year 12 Physics group link https://isaacphysics.org/account?authToken=T9CX99		14
Complete the assigned Isaac Physics task A1, A3, A4 (there are optional others (A5-A7)	Mark: /12	14
Self-assess practice questions on fundamentals of physics.	Mark: /80	15-16
Complete practice GCSE exam questions		17-24
Self-assess practice questions write your mark:	Mark: /35	25-28

What makes a successful A Level physics student?

You have chosen to study an A Level that is extremely demanding both conceptually and mathematically. It is time consuming due to the large amount of content that needs to be covered and the level of difficultly of that content. However, if you approach it with the right attitude and succeed, you will find it very rewarding. It is one of the most highly regarded A Levels for a reason and you will gain an extremely well respected qualification that will open many doors.

Complete the reflections below. This is not a way of the school trying to catch you out, it is a way of identifying your weaker areas so you know what you need to do to make sure you do not fall behind or end up with a grade that you are disappointed with.

Do you have what it takes to be successful at A Level physics?

Self-assessment	**Did you do this in year 11?**	**Do you have the *self-discipline* to do this at Post-16?**
I read around the subject as part of my independent study		
I review marked work and correct answers without my teacher having to force me		
I attend intervention sessions		
I asks for help when I'm unsure in lessons (I'm proactive)		
I know the how important it is to refer to the specification		
I use PLCs to identify weak areas and focus on these during revision		
I practice past paper questions and study the mark schemes		
I am fully engaged in class activities and don't let someone else do all the work		
I ensures that I understand a concept to the point where I can clearly explain it to someone else, if not, I do something about it		
I recognise the importance of using formula and laws to justify my answers		
I attempt all questions on worksheets and persevere when I find it challenging		
I catch up on missed work (classwork and homework)		
I ensure I learn and use new vocabulary in my answers		
I plan longer answers and tackle them in using a step by step approach		
I am willing to give up my lunch/break time to seek help if necessary		
I uses study periods effectively		
I try different revision techniques to find one that suits me, and I'm willing to change technique if it isn't working		
I try to make links between the different topics studied		
I asks questions beyond the scope of the specification		
I accept that making mistakes is a vital part of learning (and science!) and view these with a positive attitude, reflecting on the mistakes and adapting my thinking.		

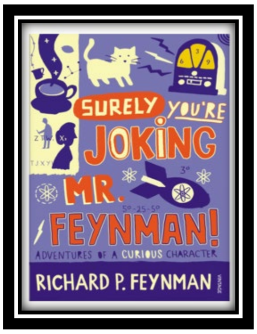
Students who struggle…

Self-assessment	Is this you?	Is this something you think you can change?
Don't ask for help when unsure		
Will look to take the easy way out when trying to solve problems (e.g. ask other people how they did it, copying mark schemes or other people's work)		
Are scared of getting wrong answers so won't write an answer		
Sit next to people they want to talk to rather than work with		
Miss homeworks or hand in incomplete homeworks		
Limit their sources of information to the teacher and textbooks		
Are disorganised		
Don't review their notes on a regular basis		
Talk in lessons and/or don't pay attention		
Leave it until later to seek help, assuming it will all be alright in the end		
Try to cram all their revision in just before the exam… because that worked at GCSE		
Lack belief in themselves and their ability in the subject		
Try to just memorise answers to questions rather than understand them		
Don't use keywords in their answers		
Are ill equipped for lessons and sometimes even exams e.g. no calculator!		
Turn up late to lessons		
Don't show workings in their calculations		
Do not use their notes or text books when completing homework		
When given past papers to complete, looks up the mark scheme hopes the teacher does not realise		
Make excuses for not completing work or not doing well in tests rather than address the problem		
Do not learn definitions and laws		
When absent, don't collect notes and think they don't have to do the homework		
Do not come to intervention		
Are defensive when the teachers talks to them- assumes it is to tell them off		

Reading list

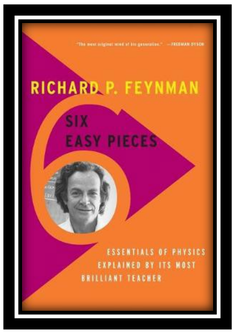
Choose one book from this list to read over the summer and then write 250 words about anything you learnt from the book or found interesting. You may choose another physics related book if you wish.

1. **Surely You're Joking Mr Feynman: Adventures of a Curious Character by Richard Feynman**



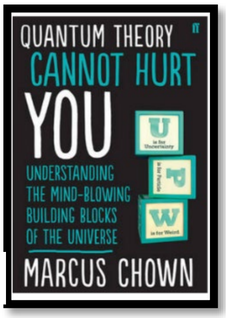
ISBN - 009917331X
Richard Feynman was a Nobel Prize winning Physicist. In my opinion he epitomises what a Physicist is. By reading this book you will get insight into his life's work including the creation of the first atomic bomb and his bongo playing adventures and his work in the field of particle physics.

2. **Six Easy Pieces: Essentials of Physics Explained by its Most Brilliant Teacher by Richard Feynman**



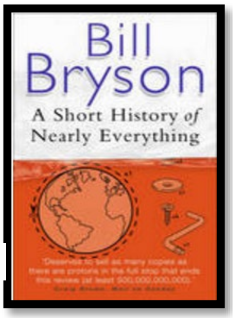
ISBN - 9780465025275
Another one by Richard Feynman. Why? Because he is widely regarded as a physics teaching legend. His six easy pieces are on atoms, basic physics, energy, gravitation, quantum mechanics, and the relationship of physics to other topics; an excellent introduction to the course. (There is also a book called 6 not so easy pieces if you're interested).

3. **Quantum Theory Cannot Hurt You: Understanding the Mind-Blowing Building Blocks of the Universe by Marcus Chown**



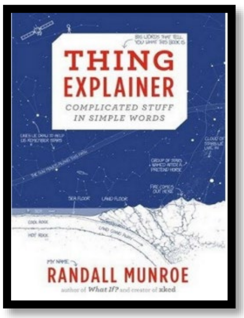
ISBN - 057131502X
Any Physics book by Marcus Chown is an excellent insight into some of the more exotic areas of Physics that require no prior knowledge. In your first year of A-Level study you will meet the quantum world for the first time. This book will fill you with interesting facts and handy analogies to whip out to impress your peers!

4. **A Short History of Nearly Everything by Bill Bryson**



ISBN – 0552997048
A modern classic. Popular science writing at its best. A Short History of Nearly Everything Bill Bryson's quest to find out everything that has happened from the Big Bang to the rise of civilization - how we got from there, being nothing at all, to here, being us. Hopefully by reading it you will gain an awe-inspiring feeling of how everything in the universe is connected by some fundamental laws.

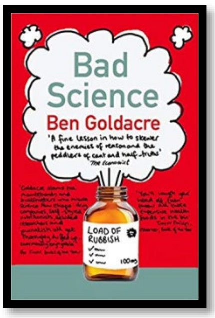
5. **Thing Explainer: Complicated Stuff in Simple Words by Randall Munrow**



ISBN – 1408802384

This recommendation is a bit of a wild-card – 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. This would be an excellent coffee table book in the home of every scientist.

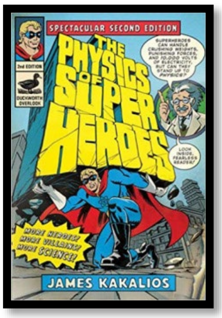
6. Bad Science by Ben Goldacre



ISBN – 000728487X

Every scientist should read this at some point, preferably before they start any research they may want to do at university level! Since 2003 Dr Ben Goldacre has been exposing dodgy medical data in his popular *Guardian* column. This book is quite funny and also eye opening when it makes you consider how quick the media, including supposed scientific media outlets, is to publish work with little to no scientific basis or huge amounts of bias. It also talks you through various pseudoscience, giving you some nice arguments to make whenever somebody tries to insist that treatments such as homeopathy work.

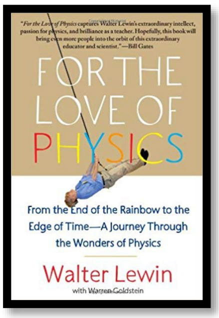
7. The Physics of Superheroes by James Kakalios



ISBN – 0715639110

If superheroes stepped off the comic book page, could they actually work their wonders in a world constrained by the laws of physics? How strong would Superman have to be to 'leap tall buildings in a single bound'? Could Storm of the 'X-Men' possibly control the weather? With the Marvel Universe being so popular, use this book to annoy your friends (or for me, siblings) who both hate and love it 'Well *actually*… according to the laws of physics, superman could….'

8. For the Love of Physics: From the End of the Rainbow to the Edge of Time - A Journey Through the Wonders of Physics by Walter Lewin (Author), Warren Goldstein (Contributor)



ISBN - 145160713X

I haven't read this one myself yet, but thought it looked interesting. Here is the blurb:
A wonderful raconteur, Lewin takes readers on a marvellous journey with him in For the Love of Physics, opening our eyes as never before to the amazing beauty and power of all that physics can reveal to us. He describes the coolest, weirdest facets of the tiniest bits of matter, the wonders of our everyday lives-such as the mysteries of why lighting strikes and what makes musical harmony happen-and the most awesome features of the outer reaches of the universe. Whether explaining why the air smells so fresh after a lightning storm or showing us that a flea is strong enough to pull a heavy book across a table, Lewin always entertains as he edifies. For the Love of Physics is a rare gem that will change the way readers see the world.

Movie / Video Clip Recommendations (optional)

These cannot be watched instead of the reading but you can use them out of interest or for research purposes

Science Fictions Films

1. **Moon (2009)**
2. **Gravity (2013)**
3. **Interstellar (2014)**
4. **The Imitation Game (2015)**
5. **The Prestige (2006)**
6. **Apollo 13 (1995)**
7. **The Theory of Everything (2014)**

Online Clips / Series

1. **Chernobyl** _ watch it if you have Sky if you haven't already done so!
2. **Minute Physics –** Variety of Physics questions explained simply (in felt tip) in a couple of minutes. Addictive viewing that will have you watching clip after clip – a particular favourite of mine is "Why is the Sky Dark at Night?"

   https://www.youtube.com/user/minutephysics

3. **Wonders of the Universe / Wonders of the Solar System –** Both available of Netflix as of 17/4/16 – Brian Cox explains the Cosmos using some excellent analogies and wonderful imagery.
4. **Shock and Awe, The Story of Electricity –** A 3 part BBC documentary that is essential viewing if you want to see how our lives have been transformed by the ideas of a few great scientists a little over 100 years ago. The link below takes you to a stream of all three parts joined together but it is best watched in hourly instalments. Don't forget to boo when you see Edison. (alternatively watch any Horizon documentary – loads of choice on Netflix and the I-Player)

   https://www.youtube.com/watch?v=Gtp51eZkwoI

5. **NASA TV –** Online coverage of launches, missions, testing and the ISS. Plenty of clips and links to explore to find out more about applications of Physics in Space technology.

   http://www.nasa.gov/multimedia/nasatv/

6. **The Fantastic Mr. Feynman –** I recommended the book earlier, I also cannot recommend this 1 hour documentary highly enough. See the life's work of the "great explainer", a fantastic mind that created mischief in all areas of modern Physics.

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

7. **The Feynman lectures -** You can also access some of Richard Feynman's lectures which were described as 'The best science lectures I've ever seen' by Bill Gates… and Miss Childs.
   https://www.microsoft.com/en-us/research/project/tuva-richard-feynman/?from=http%3A%2F%2Fresearch.microsoft.com%2Fapps%2Ftools%2Ftuva%2Findex.html

Fundamentals of physics

Below are ten topics that are essential foundations for you study of A-Level Physics. Each topic has example questions and links where you can find our more information as you prepare for next year.

Symbols and Prefixes

At A level, unlike GCSE, you need to remember all symbols, units and prefixes. Below is a list of quantities you may have already come across and will be using during your A level course. Fill in the missing standard units and powers of 10. Then learn them off by heart.

Quantity	Symbol	Unit
Velocity	v	m/s
Acceleration	a	
Time	t	
Force	F	
Resistance	R	
Potential difference	V	
Current	I	
Energy	E or W	
Pressure	P	
Momentum	p	
Power	P	
Density	ρ	
Charge	Q	

Prefix	Symbol	Power of ten
Nano	n	x 10^{-9}
Micro	µ	
Milli	m	
Centi	c	
Kilo	k	
Mega	M	
Giga	G	x 10^{9}

Solve the following:

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 eV in 0.511 MeV? Express in standard form.
10. How many m in 11 km? Express in standard form.

Standard Form

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.

Rearranging formulae

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

Significant figures

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

Give the following to 3 significant figures:

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

Calculate the following to a suitable number of significant figures:

6. 63.2/78.1
7. 39+78+120
8. (3.4+3.7+3.2)/3
9. 0.0256 x 0.129
10. 592.3/0.1772

Indices

In GCSE maths you would have learnt how to simplify equations where terms were raised to different powers. This is a skill you need to use in A Level physics when rearranging equations but also (and more importantly) when analysing units.

If you need to, revise this using this website: http://www.bbc.co.uk/education/guides/zwf8jxs/revision/1

Simplify the following and write your answers so that **none of them are written as fractions**:

1) x^2x^4
2) y^3y^{-2}
3) $m^{-5}n^4m^2n^7$
4) $\frac{1}{k^2}$
5) $\frac{5p}{z^2}$
6) $\frac{f^3}{f^2s^4}$
7) $\frac{x^2d^5a^{-3}}{xd^2}$
8) $\frac{g^3h^4}{g^2} \times \frac{g^{-4}f^2}{h^2}$
9) $\frac{m^3r}{v^3} \times v^{-1}r^{-2}$
10) $(gms^{-2} \times m) \div s$

Recording Data

Whilst carrying out a practical activity you need to write all your raw results into a table. Don't wait until the end, discard anomalies and then write it up in neat.

Tables should have column heading and units in this format quantity/unit e.g. length /mm

All results in a column should have the same precision and if you have repeated the experiment you should calculate a mean to the same precision as the data.

Below are link to practical handbooks so you can familiarise yourself with expectations.

Read pages 51-57 of the following guide: http://www.ocr.org.uk/Images/295483-practical-skills-handbook.pdf

Below is a table of results from an experiment where a ball was rolled down a ramp of different lengths. A ruler and stop clock were used.

1) Identify the errors the student has made.

	Time			
Length/cm	**Trial 1**	**Trial 2**	**Trial 3**	**Mean**
10	1.45	1.48	1.46	1.463
22	2.78	2.72	2.74	2.747
30	4.05	4.01	4.03	4.03
41	5.46	5.47	5.46	5.463
51	7.02	6.96	6.98	6.98
65	8.24	9.68	8.24	8.72
70	9.01	9.02	9.0	9.01

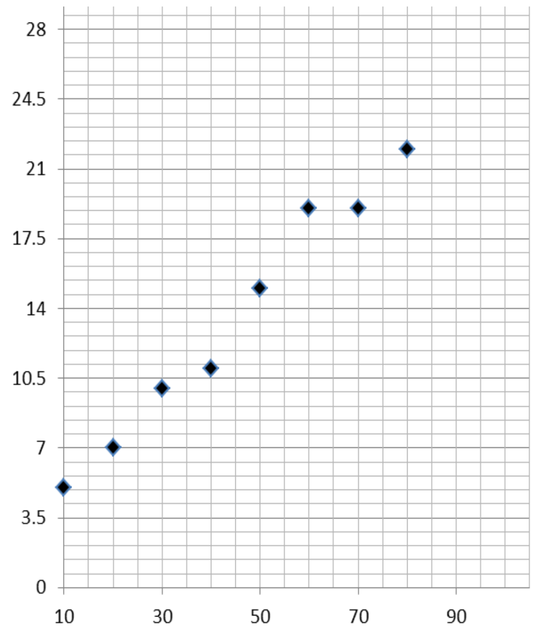
Graphs

After a practical activity the next step is to draw a graph that will be useful to you. Drawing a graph is a skill you should be familiar with already but you need to be extremely vigilant at A level. Before you draw your graph to need to identify a suitable scale to draw taking the following into consideration:

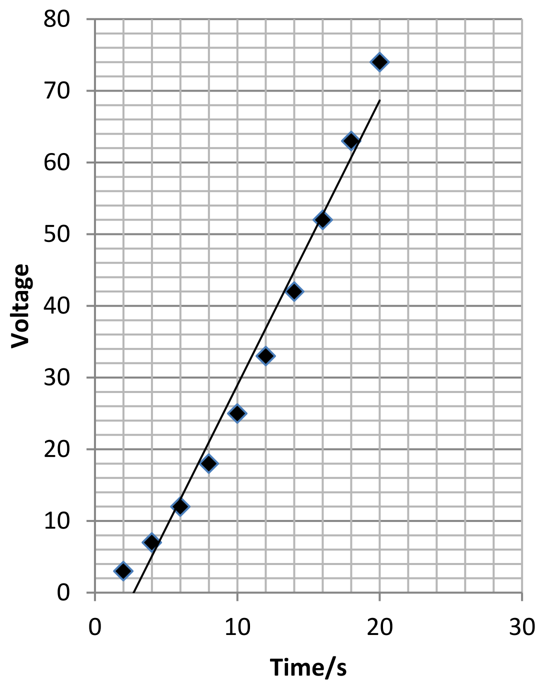
- the maximum and minimum values of each variable
- whether 0.0 should be included as a data point; graphs don't need to show the origin, a false origin can be used if your data doesn't start near zero.
- the plots should cover at least half of the grid supplied for the graph.
- the axes should use a sensible scale e.g. multiples of 1,2, 5 etc)

Identify how the following graphs could be improved

Graph 1



Graph 2



Use these answers to self-assess your work and write your score on the task tick sheet.

Similar mathematical questions will appear in your start of year exam.

Quantity	Symbol	Unit
Velocity	v	m/s
Acceleration	a	m/s^2 or 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	kgm/s or $kgms^{-1}$
Power	P	W
Density	ρ	kg/m^3 or kgm^{-3}
Charge	Q	C

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

Symbols and prefixes

1. 2400
2. 8 100 000
3. 326 000 000 000
4. 54.6
5. 240 000
6. 1.8 x 10^{-8}
7. 6.32 x 10^{-7}
8. 1.002

9. 5.11×10^{-5}
10. 1.1×10^{4}

Standard Form:

1. 2.53
2. 2.8
3. 7.7
4. 9.1
5. 1.872
6. 1.22
7. 2400
8. 35.05
9. 8 310 000
10. 600.2
11. 0.00015
12. 4300

Rearranging formulae

1. h= E/ (m x g)
2. I = Q/t
3. m = (2 x E)/v^2 or E/(0.5 x v^2)
4. $v = \sqrt{\frac{2E}{m}}$
5. u = v – at
6. a = (v-u)/t
7. s = (v^2 – u^2) / 2a
8. $u = \sqrt{v^2 - 2as}$

Significant figures

1. 3.35
2. 40.7
3. 0.839
4. 1.02
5. 60.0
6. 0.809
7. 237
8. 3.4
9. 0.00330
10. 3343

Indices

1. x^6
2. y
3. $m^{-3}n^{11}$
4. k^{-2}
5. $5pz^{-2}$
6. fs^{-4}
7. xd^3a^{-3}
8. $g^{-3}h^2f^2$
9. $m^3r^{-1}v^{-4}$
10. gm^2s^{-3}

Recording data (1 mark for each point)

- Time should have a unit next to it
- Length can be measured to the nearest mm so should be 10.0, 22.0 etc
- Length 65 trial 2 is an anomaly and should have been excluded from the mean
- All mean values should be to 2 decimal places
- Mean of length 61 should be 6.99 (rounding error)

Graphs (1 mark for each point)

Graph 1:

- Axis need labels
- Point should be x not dots
- Line of best fit is needed
- y axis is a difficult scale
- x axis could have begun at zero so the y-intercept could be found

Graph 2:

- y-axis needs a unit
- curve of best fit needed not a straight line
- Point should be x not dots

Practice exam questions

Now complete these past paper questions to review this content. Your start of year assessment will be based on similar questions.

Answers are at the end, use these to self-assess and write your score in the task tick sheet.

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

....

.... **[1]**

(b) Fig. 1.1 shows two sets of quantities listed as 'scalars' and 'vectors' by a student.

scalars	vectors
acceleration	displacement
pressure	energy
stress	power
time	velocity
volume	weight

Fig. 1.1

(i) State the one quantity that has been incorrectly listed as a scalar.

.... **[1]**

(ii) State two quantities that have been incorrectly listed as vectors.

1. ....

2. .... **[1]**

(c) Circle the correct value for the prefix tera (T) in the list below.

10^6 10^9 10^{12} 10^{15} **[1]**

(d) Rearrange the following prefixes in the order of smallest to largest.

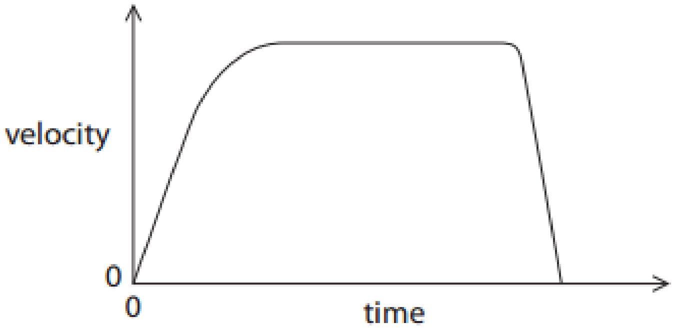
μ c p k

.... **[1]**

[total 5 marks]

1 A toy car rolls down a ramp and hits a cushion.

The graph shows how its velocity changes with time.



(a) Constant velocity on the graph is shown by

(1)

- ☒ **A** the area under the line
- ☒ **B** the horizontal part of the line
- ☒ **C** the sloping line at the end
- ☒ **D** the sloping line at the start

(b) The distance travelled is shown by

(1)

- ☒ **A** the area under the line
- ☒ **B** the horizontal part of the line
- ☒ **C** the sloping line at the end
- ☒ **D** the sloping line at the start

(c) The average velocity of the toy car is given by

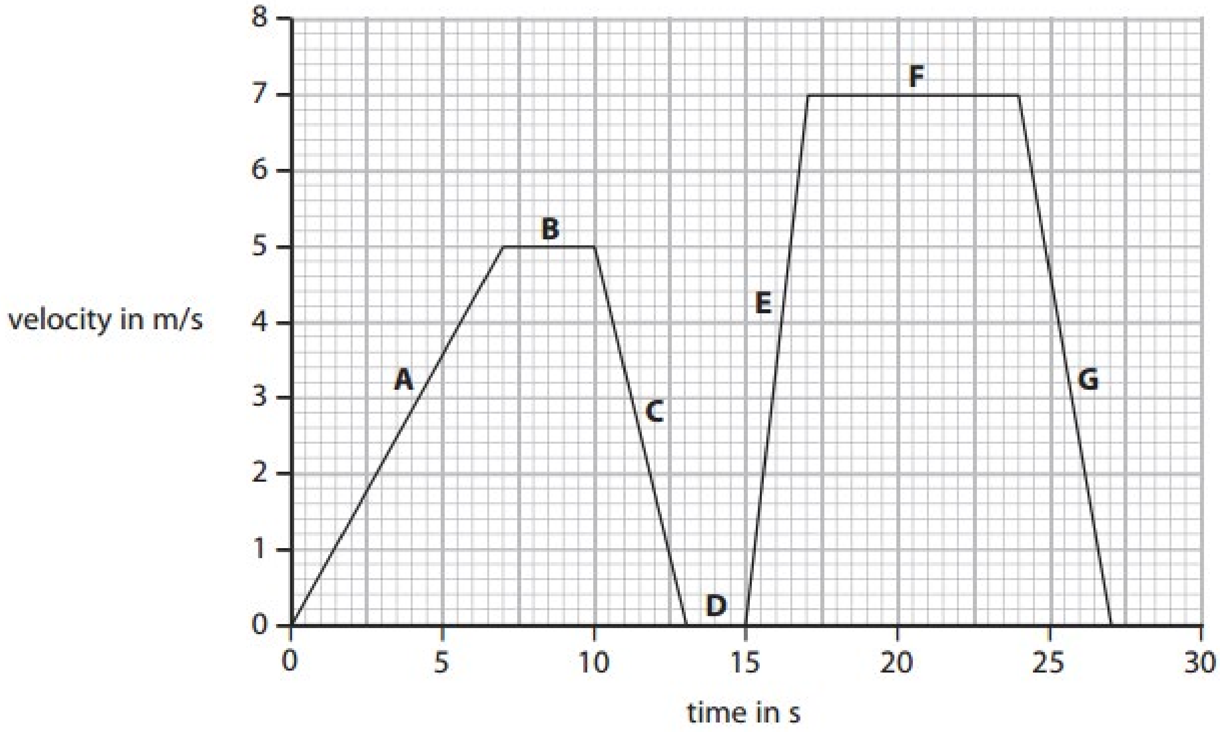
(1)

- ☒ **A** the change in velocity divided by the time taken
- ☒ **B** the distance moved divided by the time taken
- ☒ **C** the time taken divided by the change in velocity
- ☒ **D** the time taken divided by the distance moved

(Total for Question 1 = 3 marks)

5 A student cycles to school.

The graph shows the stages A to G of the journey.



(a) Describe the motion of the student during stages B and D.

(2)

Stage	Description
B	
D	

(b) State how the graph shows that the acceleration for stage E is greater than the acceleration for stage A.

(1)

....

....

....

(c) Calculate the distance that the student travels in the last 10 s of the journey.

(4)

distance = ... m

(d) The total distance travelled is 106.5 m.

Show that the average speed of the journey is about 4 m/s.

(3)

11 An underground train enters a station.

© Tom Page

(a) The mass of the train and its passengers is 250 000 kg.

The total kinetic energy is 18 MJ.

(i) State the relationship between kinetic energy (KE), mass and velocity.

(1)

(ii) Calculate the velocity of the train as it enters the station.

(3)

velocity = ... m/s

(iii) The driver applies the brakes to stop the train.

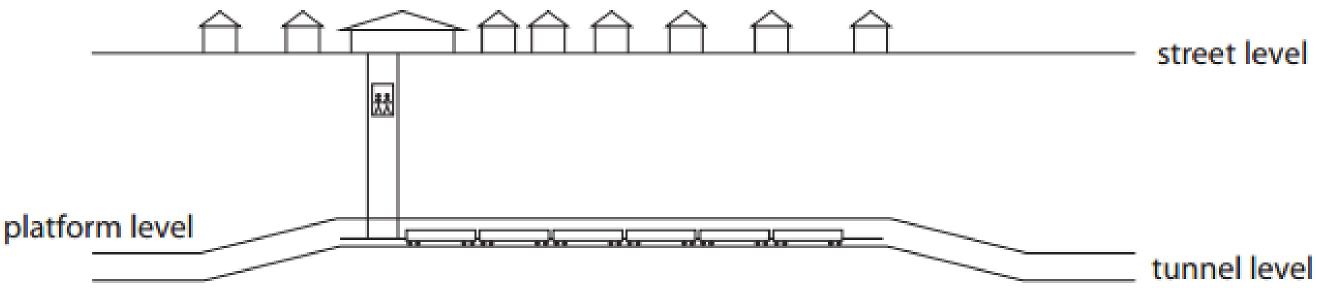
State what happens to the kinetic energy of the train.

(1)

....

....

(b) The diagram shows a section through the station.



(i) The passengers who use the station are carried from platform level to street level in a lift.

Explain why these passengers gain gravitational potential energy in the lift, even when they are below ground.

(2)

....

....

....

....

(ii) The tunnel is designed so that the trains go up a slope as they enter the station and go down a slope as they leave.

The driver uses brakes to stop the train in the station and a motor to make the train move away.

Explain how the sloping parts of the tunnel affect the amount of work that needs to be done on the train by the brakes and by the motor.

(4)

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(Total for Question 11 = 11 marks)

(c) The machine lifts a load weighing 400 000 N through 190 m.

(i) State the relationship between work done, force and distance moved.

(1)

(ii) Calculate the work done on the load.

(2)

work done on load = ... J

(d) The machine uses an average (mean) power of 1.9 MW to do 67 MJ of work.

(i) Calculate the time needed to do this work.

(3)

time = ... s

(ii) State the effect of using a lower average power to do this work.

(1)

....

Markschemes

Question			Answer	Marks	Guidance
1	(a)		A vector quantity has direction / scalar quantity does not have direction	B1	**Not**: 'Scalar only has magnitude' because there is no mention of direction
	(b)	(i)	acceleration	B1	
		(ii)	power and energy	B1	
[redacted]					
	(c)		10^{12}	B1	
	(d)		*p μ c k*	B1	
			Total	**7**	

Question number		Answer	Notes	Marks
1	(a)	B – the horizontal part of the line;		1
	(b)	A – the area under the line;		1
	(c)	B – the distance moved divided by the time taken;		1

Total 3 marks

Question number		Answer	Notes	Marks
5 (a) B D		constant velocity of <u>5 m/s</u> Idea that velocity/speed = 0	Allow speed is <u>5 m/s</u> Allow "stops", "stationary","at rest"	2
(b)		Idea of greater slope (for stage E); e.g. the gradient is steeper	Allow reverse argument, provided stage A is identified e.g. "stage A has a shallower slope" Allow attempts to demonstrate through - calculation of both gradients - qualitative comparison of data	1
(c)		distance = speed × time OR distance = area under graph; attempt to find any area; attempt to total correct areas (or use trapezium method); evaluation; e.g. distance = area under graph 7 × 7 or ½ × 7 × 3 (7 × 7) + (½ × 7 × 3) = 49 + 10.5 59.5 (m)	The correct relationship can be **implicit** in the working 59.5 (m) with no working = full marks Allow the trapezium method - e.g. 7 × ((7+10) ÷ 2) = 7 × 8.5 = 59.5 (m)	4
(d)		Correct equation shown ; e.g. (average speed) = distance (moved) / time (taken) Substitution of correct distance and suitable time; Correct evaluation ; e.g.106.5/27 3.94 (m/s)	Allow d/t Allow (ecf) max 2 4.26 (m/s) (use of time = 25 s) 3.55 (m/s) (use of time = 30 s) Allow reverse argument max 2 e.g. 106.5 ÷ 4 = 26.6 (s)	3

11	(a)	(i)	kinetic energy = ½ × mass × velocity^2	Accept symbols KE = ½ × m × v^2	1
		(ii)	Conversion of units; Substitution and rearrangement into correct formula; Calculation; e.g. 18 MJ = 18 000 000 J v^2 = 18 000 000 × 2 ÷ 250 000 (= 144) v = 12 (m/s)	at any stage POT error max 2 marks e.g. 3.8 x 10^n or 1.2 x 10^n	3
		(iii)	Energy is transferred to surroundings;	Allow to heat, sound, other forms / energy decreases	1
	(b)	(i)	Any two of - MP1. GPE = m.g.h; MP2. passengers have moved to a higher point/upwards; MP3. work is done to move the passengers; MP4. passengers are further from the centre of the earth;	allow 'lift' for 'passengers' 'gravity force' (still) acts below ground level, reject 'gravity' moved in opposite direction to force of gravity	2
		(ii)	max of 3 from each list to total of 4 **When entering station-** MP1. KE → GPE; MP2. Less work done by the brakes (to stop the train); MP3. Less (braking) force needed (to stop) ; MP4. train stops more quickly OR brakes are needed for less time (to stop); **When leaving station-** MP5. GPE → KE; MP6. Less work done by the motor (to accelerate); MP7. Less force needed (to accelerate the train); MP8. train accelerates more quickly OR force needed for a shorter time (to reach a given speed);	Allow energy for work an effect on the brakes, e.g. don't get so hot / are quieter / last longer / are less worn Allow less power/ current needed motor lasts longer / is less worn	4

Total 11 marks

Question number			Answer	Notes	Marks
9	(c)	(i)	work done = force × distance (moved)	Accept symbols W=F×d W =Fd	1
		(ii)	Substitution; Calculation; e.g. Work = 400 000 × 190 76 000 000 (J)	Accept 76 MJ with correct unit 7.6 x 10^7 (J) 76 x 10^6 (J)	2
	(d)	(i)	Substitution into given equation; P = W/t Rearrangement; Calculation; e.g. 1.9 = 67 ÷ t..............worth 1 t = 67 ÷ 1.9 ....worth 2 = 35 (s)......................worth 3	No mark for the equation as it is given in QP Substitution and rearrangement in either order Or (in joules and watts) 67 000 000 ÷ 1 900 000 (35.26) correct answer without working =3	3
		(ii)	Any one of :- Takes longer /eq; More time needed to raise coal; Load moves more slowly;	Ignore: unqualified comments about the amount of work done	1

Total 15 marks