Physics Newsletter

October 2020

Hi guys!

This newsletter was not written by your usual A level physicists, but the Year 12s, and we will alternate monthly. Not that this will affect your monthly dose of physics, so we hope you enjoy our first edition of the physics newsletter :)
Don't forget you can ask us any questions raised by our articles: just send us an email. Also, if you want to contribute to the next newsletter, please email us by 9th November.

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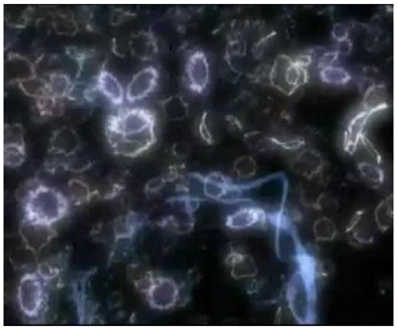
In this edition we will discuss:

- String theory
- Internal combustion engines
- Quantum computers

Can Strings Replace Particles? - String Theory Explained

We've all heard of string theory but does anyone really understand what it is beyond a cool sounding physics concept? Well, there's no need to worry; this article shall explain this weird theory which completely revolutionises our perspective of the universe. Get ready to throw the idea of particles out of your head, and welcome jiggles in space to define everything we know.

The origins of string theory revolve around finding an explanation for gravity in the quantum world. Gravity is a very different force compared to the others we know of (electromagnetism, the weak and the strong force). These all interact on a miniscule scale, whereas gravity currently has no explanation for how it acts on smaller particles that are almost massless. Moreover, gravity does not actively play a role in our universe, it is simply an effect of the warpage of space and time (our space joint with time, where gravity affects time). One of the aims of all physicists, since the dawn of this subject, is to find a unifying theory that describes all of the forces' interactions under a single idea, AKA Unified Field Theory (UFT) for the sake of sciency names. Even Einstein was tantalised by the idea of a UFT during the latter part of his career and many scientists believe that string theory is the possible solution for this conundrum.



Now for the explanation of string theory. Just as the plucking of a guitar string at different frets can give you a different note, the plucking of this quantum string can give you a different elementary particle. Not a literal pluck, but it is an analogy that the different vibrational properties of these strings e.g string, tension, frequency etc can give you different fundamental particles like an electron or neutrino for example. Additionally, these strings can merge and or divide into two separate strings. The emission of one particle e.g. an electron would correspond to a string dividing, and the absorption of a particle e.g. a neutrino would be the joining of two strings. And finally, these strings are twisted and squished inside these fundamental particles , for example in quarks (an elementary particle).

Therefore, if the graviton can be produced from the "pluck" of a string, then we have successfully found a solution to a problem that has befuddled the minds of many.

But wait, what is a graviton and why does it solve anything?
Gravitons would be the exchange particles (these cause an interaction between particles to produce a physical effect e.g. repulsion) of the force of gravity. Consequently, we could describe gravity in terms of quantum mechanics using these strings, which is the aim for the 21st century.

Why use strings to explain the existence of a graviton, can it not be a particle?

Strings make more sense than gravitons being particles as they would have infinite energy when interacting with each other, which doesn't make sense mathematically let alone to us. It's simply impossible on such a small scale, and scientists have thought of proving the existence of a particle graviton, but the energy required to detect one would give birth to a blackhole (just as electron microscopes give a greater degree of resolution because they use more energy than a light microscope for example). So detecting a graviton is not something we want to try any time soon. Many physicists have additionally had a hard time quantising gravity as a particle; strings would make life much easier. On the whole it is way simpler to describe them as high energy dancing filaments.

Why can we not prove that string theory exists?
Physics must be backed up by mathematics, and the amount of mathematics involved in this theory is incredible. It involves 10/11 other dimensions, and only at these dimensions is the theory consistent. However, we live in the 4th dimension (height, width, length, and our passage through time), and in order to get string theory to work normally in our universe, we would need to cancel out 6 dimensions which is mathematically difficult (quite an understatement). To this day we do not have a solution.

There you have it, string theory described in two pages. An obscure yet fundamentally simple hypothesis that could be a candidate to finally link gravity with the rest of the forces. If this theory is one day proven to be true, then all minds will be blown. Seeing the universe as just a sea of waves will totally revolutionise physics that we know today. If it does happen any time soon, you'll finally understand what a monumental discovery it would be.

Here are the resources I used to write this article. I hope you found it ..understandable

- https://www.space.com/17594-string-theory.html
- https://www.youtube.com/watch?v=TI6sY0kCPpk

- https://www.newscientist.com/article/dn16950-string-theory-a-beginners-guide/
- https://www.smithsonianmag.com/science-nature/string-theory-about-unravel-180953637/
- https://www.space.com/quantum-gravity.html
- https://www.youtube.com/watch?v=kF4ju6j6aLE

- Vanshika Gupta 12P

The Mechanics Of An Internal Combustion Engine

Well guys we all love searching for answers to explain our very existence and the universe we live in, but for now we're jumping out of the quantum realm to see how we can apply concepts of motion and energy in our everyday lives… well maybe not quite so everyday. We'll be looking at how one of the most important things in our lives works, the engine:

How a basic internal combustion engine works:

Combustion, or burning, is the chemical process of releasing energy from oxygen, in air, with fuel. In an internal combustion engine the process happens… well internally (safe to say it can be assumed from the name), so when this reaction occurs in the engine, the engine itself then partially converts or uses this energy to work.

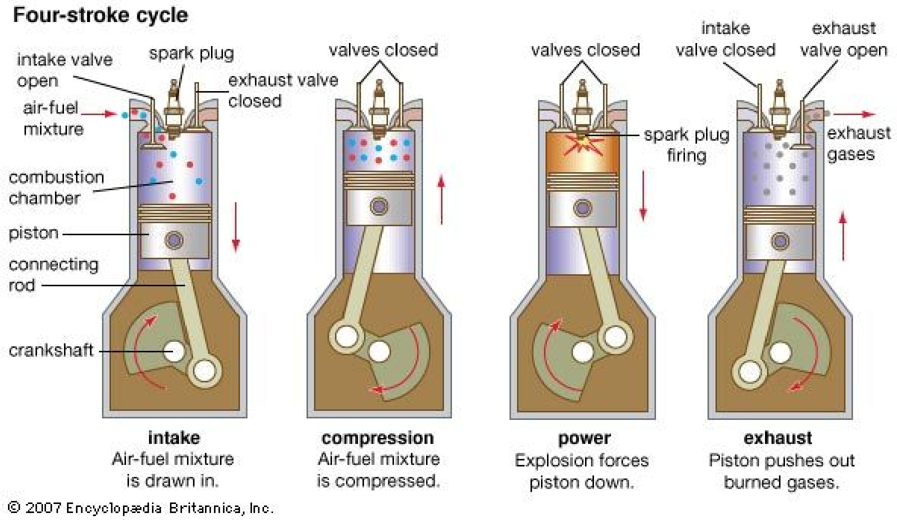
There are two types of internal combustion engine in production currently: the spark ignition petrol engine and the compression ignition diesel engine. Both are mostly four-stroke cycle engines which simply means that the piston needs to move in four strokes to complete a cycle. The key processes within the engine are:

- Intake
- Compression
- Combustion/ Power
- Exhaust

The key differences between the two types of engine are how they deliver and ignite the fuel, otherwise most of the other processes are the same. The petrol engine, which is explained in further detail below and shown in the diagram, mixes the fuel and air before being taken into the cylinder for compression and is then ignited by a spark. However in a diesel engine, only air is inducted into the engine and then compressed. Diesel engines then spray the fuel into the hot compressed air at a suitable, measured rate, which causes ignition, with some help from glow plugs. The reason there is a difference between the two is because the viscosity (gloopiness) and flammability of the two fuels differ. Since petrol is runnier/ has a lower viscosity (because of its shorter carbon chain) it can be mixed with the air more easily and be carried throughout the car with less difficulty. Petrol is also more flammable than diesel so can ignite easily from a small spark. Diesel, on the other hand, needs to be under intense pressure and have a sustained flame (which comes from the glow plugs) in order to ignite.

How the petrol engine works:

The engine consists of fixed cylinders with a moving piston inside each of them. Fuel injectors spray pressurised fuel directly into the engine, while the air flows into the cylinders. Then the air-fuel mixture rushes into the combustion chamber because the downward movement of the piston creates a vacuum (this is because when there is a difference in pressure, particles rush to where there is less pressure). The piston then moves up compressing the mixture of fuel and air. A spark plug then creates a spark through an electric current. This electric current/ spark then ignites the air- fuel mixture resulting in an explosion inside of the engine. The expanding gases produced during this explosion then lifts up the piston, which then rotates the crankshaft. Ultimately, through systems of gears and other constituents of the vehicle, this motion drives the wheel's motion moving the entire vehicle getting you where you need to go.



So as interesting as this may be, what's the point of learning about how an internal combustion engine works, when the advent of the electric power unit is probably going to render it obsolete? Well, although we're aiming to cut down on our consumption of fuels such as diesel and petrol to aid the environment, the internal combustion engines can still potentially use renewable or alternative fuels such as natural gas, propane, biodiesel or ethanol rather than petrol or diesel (essentially anything that is a flammable liquid* could theoretically be used to fuel an ICE). The world also still needs time to adapt and make way for electric engines by making more charging stations for cars so in the meantime ICEs can be used in conjunction with electric sources to create hybrids.

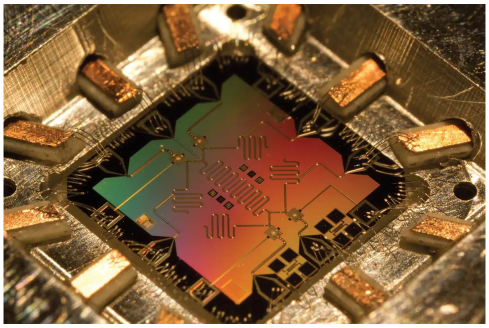
* Since, theoretically, a combustion engine could run on any flammable liquid, why not vegetable oil? To find out how it works you can look on the following website: https://auto.howstuffworks.com/fuel-efficiency/fuel-consumption/vegetable-oil-fuel.htm

- Siyma Chowdhury 12SW

Quantum Computers

You've probably heard the term 'quantum computer' before. It's something we hear a lot, without actually receiving any proper explanation as to what it is, how it works, why it's even such a big deal. The reason may be that a quantum computer is a complex device, and it is difficult to explain how it works without being quite familiar with the field of quantum mechanics (which I'm not, by the way). However, don't let the phrase discourage you. Quantum computers are fascinating and definitely worth your time. In this article I will be outlining how they work, why they could be useful, and where we currently are with developing them.

A normal computer is actually a very simple device. Information is represented by bits – binary digits – which are either displayed as 1 or 0. Therefore, information in a normal computer is in one state or the other, much like an on and off switch. Computers use bits to make decisions about data based on the instructions they are given.

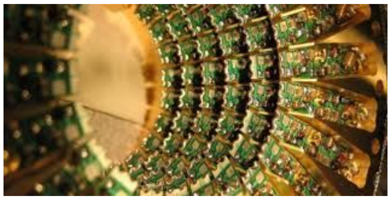


In summary, computers work the way they're expected to: according to the laws of science that we understand. Things are not quite so black and white with quantum computers. This is due to the fact they operate at a subatomic scale, and everything we think we know about physics seems to go out of the window once we get to matter this tiny. Remember that I said that information is in one state or another in a regular computer? Well, in a quantum computer, it's able to be in more than one state at once (superposition), using combinations of 0s and 1s. Therefore, instead of bits, quantum computers use quantum bits – qubits. As a way to contrast these two computers, imagine that you ask them to find their way out of a maze. A regular computer would try every option in turn – but a quantum computer could look at every route at once. What does this mean? Well, for one thing, quantum computers can store a huge amount of information and still manage to use much less energy than our normal PC, making them far more efficient.

But why do we even need a computer like this? What good does it do to meddle with an area of physics we don't even understand? Quite a lot, surprisingly. The computing industry is actually struggling at the moment. As more and more people get access to computers, we get ever closer to simply being unable to supply enough energy to power them all. Currently we think that we will reach this point in 2040. With that date in mind, the industry is scrambling to make energy-efficient quantum computers more widely available. Another great thing about them is that quantum computers can help us encrypt sensitive data to make it completely hack-free, and perform calculations that a regular computer could only dream of. We could vastly speed up the development of artificial intelligence (something Google is already using them for to improve the software of self-driving cars). Medicine could be revolutionised as we found better, cheaper drugs. The potential of quantum computing is not even fully understood yet, with many more applications waiting to be discovered.

However, it is important to note that quantum computers are not here to replace ordinary computers. Their function is to solve problems a regular PC can't, and they would not be able to provide some of the perks that a normal computer has, like emails for example.

Quantum computing as a field has only just begun. We are still struggling to find a system that works; operating on an atomic scale is difficult as any kind of vibration can impact the atoms, disrupting their function. Additionally, we have not even found a stable model for a quantum computer yet. Conditions need to be kept at -273 degrees (the point at which atoms stop vibrating – absolute zero) to keep the computers stable, for example. However, Google has pledged a viable quantum computer within the next five years, and several algorithms for quantum computers have already been developed. This field is only going to grow – and definitely worth looking into if bending the rules of physics is something you find exciting.



Are you interested in learning more? If so, I've provided some of the links I used when researching this topic below. I hope you found this article at least mildly interesting.

- https://bernardmarr.com/default.asp?contentID=1193
- https://www.aaas.org/news/why-do-we-want-quantum-computer
- https://www.ncbi.nlm.nih.gov/books/NBK538701/#:~:text=Quantum%20computers%20have%20the%20potential,great%20progress%20is%20under%20way
- https://www.forbes.com/sites/bernardmarr/2017/07/04/what-is-quantum-computing-a-super-easy-explanation-for-anyone/#33682a521d3b
- https://www.wired.co.uk/article/quantum-computing-explained
- https://www.youtube.com/watch?v=JhHMJCUmq28&list=LLiM5QdYHMNp8PStLvXyjHxg&index=1229

~ Maheen Abir 12MP :)