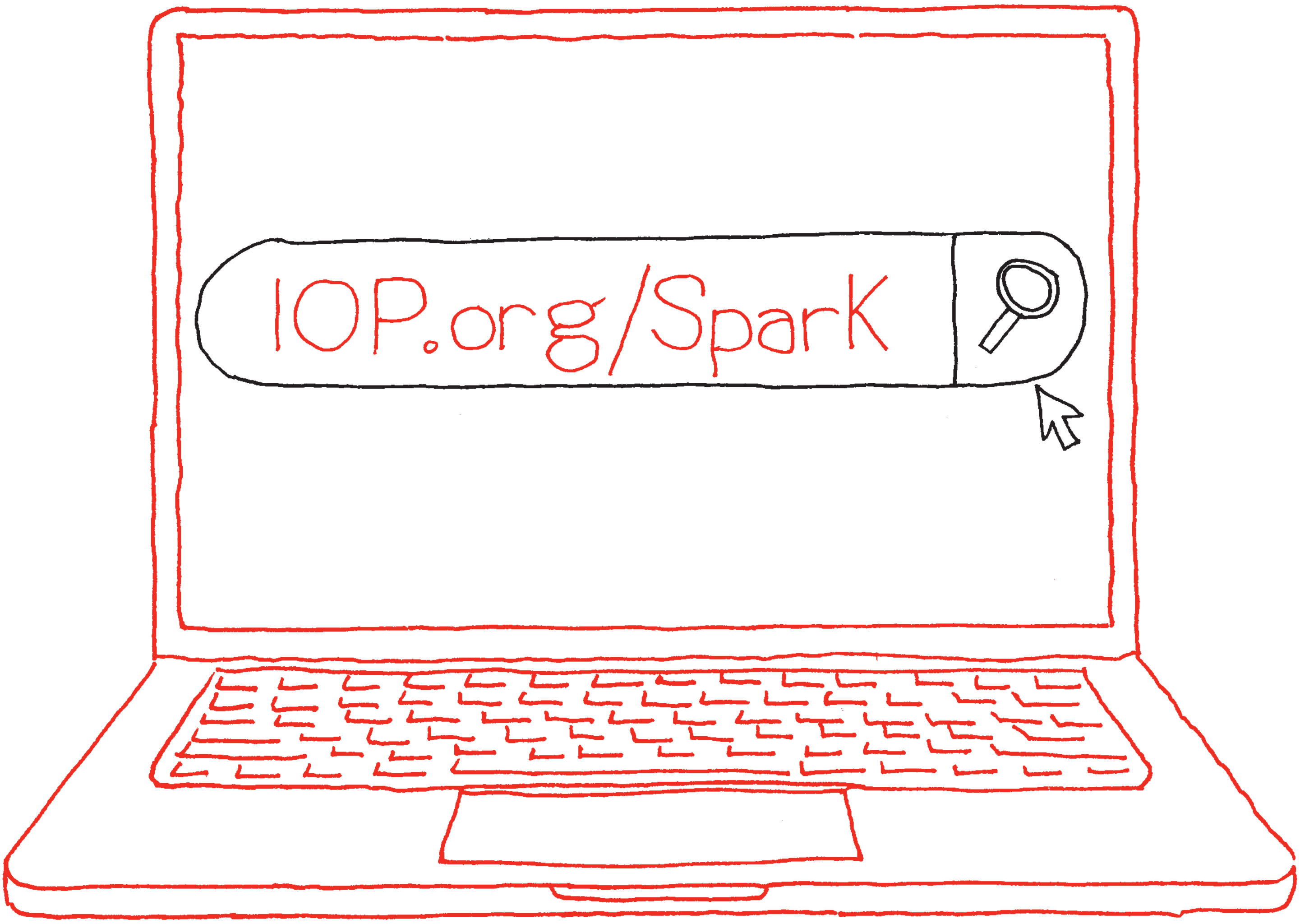
Classroom physics

The magazine for affiliated schools

September 2019 Issue 50



Introducing IOPSpark: our new website with unlimited access to 2000+ physics teaching resources.

IOP Institute of Physics

www.iop.org

IOP

A recent IOP workshop explored what we can learn from cognitive psychology, mastery questions and why SLOP (shed loads of practice) is necessary – but not sufficient – in physics education

Teaching physics is subjective

We know teachers could fill their working week three times over. And that any service or initiative that frees up time is a godsend. We hope that IOPSpark is just that. It offers all our resources in one place, a one-stop shop and a platform on which we can build. But it isn't just about lesson planning – we want IOPSpark to offer you a sliver of breathing space, and the resources, for some physics CPD.

Subject-specific CPD is enjoying something of a resurgence, driven from the chalkface. It makes sense. As a physics teacher, which course would appeal more: 'Behaviour management in the classroom' or 'Behaviour management in the physics lab'? The latter will be specifically relevant to you and you will get the most bang for your INSET buck.

At IOP we are pushing hard to put subject-specific CPD at the centre of policy-makers' thinking. We are building a consortium of subject associations to feed back to government on the Early Career Framework, pressing for subject mentoring as a mandatory element of new teacher induction. We also have a Professional Practice Group, charged with building consensus among all those individuals leading physics CPD for teachers across the UK and Ireland.

We continue to speak truth to power, pointing out that more physicists and engineers will be essential in grappling with the global, national and local challenges facing humanity. Feeding that talent pipeline starts in the classroom with a richer experience of physics. To deliver that, physics teachers need subject-specific networks and support.

Lest we forget, IOP's network of dedicated coaches leads thousands of hours of teacher CPD each year, emphasising the joy, wonder, elegance and world-changing potential of this subject we love.

By Robin Griffiths,
Head of Programme: Teacher Professional Support

Look out for CPD days near you on TalkPhysics.org or get in touch with your Regional Education Manager (see back page for contact details).

This issue

News

Resources

Digests

Opportunities

With this issue...

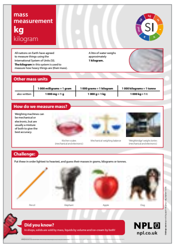
Stories from physics: forces and motion

The second booklet in our series collecting physics stories for secondary school students. This edition includes classics such as how fast a crack in a glass plate can travel, the jounce (defined as the rate of change of jerk) and studies of the motion of falling cats.

Pocket Physics

We've included our updated student revision guide for 16-18s. Affiliated schools can order a class set by emailing education@iop.org

Correction:



With the last issue of *Classroom Physics* we sent you a poster to mark the redefinition of kilogram. As some of you pointed out, the description of mass was wrong. A new version of the poster is included with this issue. It is two sided – put up whichever side is most age appropriate for your classroom.

Order a complete set of seven SI base unit posters at npl.co.uk/school-posters

And read more about massive definitions and weighty issues on page 8.

Classroom physics

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Teaching resources

IOPSpark: all our resources, all in one place

Welcome to IOPSpark

Unlimited Access to Over 2,000 Physics Teaching Resources

We bring together hundreds of teaching activities so you can find the right approach for your class.

Explore IOPSpark...

Editor's Picks

Energy

Energy and Thermal P...

We are delighted to launch our new website IOPSpark, the ‘go to’ resource for every aspect of teaching physics at school and college levels. Designed with teachers and their supporters in mind, we’ve thought long and hard about how the site is structured to make it quick and easy to navigate, offering suggested related resources and linking topics.

Charles Tracy, IOP Head of Education said, “Teaching physics today is hugely rewarding. However it can be daunting to teach something new or to teach something familiar in a new way, especially when planning time is limited. “Our hope is that IOPSpark will provide teachers with a trusted source of ideas and professional learning, whether they are looking for a quick fix or pedagogical contemplation.”

All our existing resources, including *Supporting Physics Teaching*, *Teaching Advanced Physics*, and *Practical Physics* are there, plus a brand new section of evidence-based support to address student misconceptions.

Expect the unexpected

Some hidden gems among the more conventional resources you may be more familiar with.

Butthead

A little something to enliven teaching the photoelectric effect.
spark.iop.org/butthead

Waste pipe interferometer

An unusual use of waste pipes demonstrates a clear pattern of nodes and antinodes.
spark.iop.org/acoustic-interferometer

Hacksaw blade resonator

A safe way to practise new vocabulary such as frequency, amplitude, phase and resonance.
spark.iop.org/hacksaw-blade-resonator

Pick and Mix

Explore the mechanical properties and textures of sweets and biscuits.
spark.iop.org/pick-and-mix

Volume change on dissolving salt in water

A thought-provoking experiment with a surprising result.
spark.iop.org/volume-change-dissolving-salt-water

IOPSpark in numbers

7 domains
covering pre-19 physics curriculum

Earth & Space

Electricity & Magnetism

Energy & Thermal Physics

Forces & Motion

Light, Sound & Waves

Properties of Matter

Quantum & Nuclear

150+
Marvin and Milo lesson starter and/or enrichment activities

300+
curated collections of resources, searchable by topic and student range

2,000+
resource pages

iop.org/spark

Early career teachers

Mathematics and physics teacher retention payments

The Department for Education (England) recently announced details of the mathematics and physics teacher retention payments pilot, which will run across the academic years 2019 to 2020 and 2020 to 2021.

Mathematics and physics teachers in the first five years of their career will be eligible for a £2,000 retention payment after tax.

To be eligible, teachers must have completed either an undergraduate or postgraduate mathematics or physics related degree or initial teacher training course specialising in mathematics or physics.

Teachers must also be employed in a state-funded secondary in the North East, Yorkshire and the Humber, or remaining Opportunity Areas, and can be employed on a full-time or part-time basis.

Charles Tracy, Head of Education at the Institute of Physics, said:

"The IOP welcomes an initiative that explores ways to retain new teachers of physics because it's a hugely problematic area. Currently, almost 40 per cent of newly qualified physics teachers will have left within their first five years, which is a shocking statistic and it's crucial that we work together to find ways to motivate and retain these early career professionals.

"We'll watch with interest to see how this pilot develops but, given that it's based on rigorous evidence which shows it can work, we're optimistic about the possibilities."

Find out more
teachers, schools and local authorities can register their interest and receive updates at gov.uk/guidance/apply-for-mathematics-and-physics-teacher-retention-payments. Queries can be directed to DfE via financial.incentives@education.gov.uk.

Improving gender balance

Taking action beyond the physics classroom

We're inviting schools to register for the Gender Action Schools Award. Building on our whole school approach, the award programme promotes and supports nurseries and schools to challenge stereotypes and demonstrate their commitment to ensuring all young people can reach their full potential.
The benefits of joining Gender Action are:

- Research-backed guidance and effective support for practitioners to challenge stereotypes
- Improved outcomes for children through broadened subject take-up and career goals
- National recognition of your school's support for gender equality
- An online library of reports, classroom activities and resources for all educational stages plus a blog written by educators and practitioners with advice on how to tackle gender stereotypes in different settings.

The programme is free to join. We co-founded it with King's College London, UCL Institute of Education and the University Council of Modern Languages. Although the initial funding came from the Mayor of London, we plan to roll out the award nationally and we already have over 90 Supporter schools across the UK, with 130 more registered.

genderaction

Each Supporter school has to submit plans outlining their goals to tackle stereotypes in their settings.
Examples include:

- To challenge stereotypes in options and career choices
- To ensure all displays and books reflect are diverse and representative
- To support all school staff to become aware of their biases
- To empower and inform students to be able to discuss gender issues
- To ensure playground facilities are equally accessed
- To engage with parents around these issues

Find out more and register on our website genderaction.co.uk

Professional development

Be recognised – get chartered

Are you looking for a way to show the time and effort that has gone into your professional role as a physics teacher? We'd like to encourage you to apply for Chartered Physicist status (CPhys). This isn't a qualification, but a formal recognition of your physics teaching experience. Expertise that you have built up in the professional classroom setting is just as valuable as an industrial laboratory. CPhys is equivalent to SLE accreditation, but available only to IOP members.

As a badge of professional standing, it will encourage you to reflect on your career to date. Your physics knowledge and skills are integral to your role as a teacher, as well as areas of responsibility for students and colleagues. CPhys emphasises your ongoing commitment as a physicist.

This year the process has been streamlined and this is especially helpful for teachers. You can now show Masters equivalence through your teaching qualifications and professional development. The IOP Professional Practice Group can help with examples and advice. We can also offer support with summarising your professional practice to date as well as future CPD plans. It would be great to see more teachers recognised as professional physicists. What better way to demonstrate the value of your physics subject knowledge and skills?

Find out more at membership.iop.org/chartered-physicist-cphys.
Contact TeacherCPhys@iop.org for support with your application

IOP Strategy

We've announced an ambitious new strategy to transform the physics landscape for the UK and Ireland, and ensure a thriving physics eco-system that will contribute to innovation, discovery, research, growth and debate in the UK, Ireland and beyond.

We have identified three key challenges that present the greatest barriers to unlocking the potential of physics and its impact in society: diversity and skills, unlocking capability and public dialogue.

By the end of 2023, we have six aspirations for what the landscape should look like. Education is fundamental to realising these, as the first two aspirations state:

1. every secondary school pupil in the UK and Ireland will have access to a specialist physics teacher
2. girls will make up at least 30% of those taking physics at age 16-19 and there will be double the current number of young people from black and minority ethnic and lower socio-economic backgrounds

The remaining aspirations concern research funding, non-academic routes into physics careers, academic publishing and public dialogue. Additionally, we will launching a £10 million 'challenge fund' that will seek to identify, and fund, projects with partners who share these ambitions and who can help to accelerate change.

IOP Chief Executive, Professor Paul Hardaker, commented: 'In the coming years, we will need to depend even more on knowledge and skills from physics and STEM more widely to address the challenges facing us, if we are to continue to improve diagnosis and treatment in healthcare, live more prosperously and sustainably, address significant disparities in access to water and food, resolve our energy needs and protect our biodiversity. In all these ways, and others, physics has the potential to improve our lives. But we need to act now to ensure we have the people, infrastructure, facilities and funding to unlock this huge potential.'

Find out more at
iop.org/strategy
and follow #IOPunlockingthefuture

Regional CPD

"My teaching will be transformed"

On 2 July, over 100 teachers and technicians gathered at Ivybridge Community College in Devon to attend the IOP South West Physics CPD day. The day started with a keynote from Dave Cotton entitled Tones, Tines and Tings, which covered ideas, demonstrations and stories to enrich the teaching of sound. Attendees then had the opportunity to attend three workshops, on topics ranging from exo-climatology to circuits. One happy attendee commented: "my teaching will be transformed". Explore and download the resources from the day on Talkphysics at bit.ly/TPswcpd19

Scottish teachers celebrate the Sun and Moon

This year's IOP Stirling Meeting and Scottish Physics Teachers Summer School took place in May. It was themed around the 50th anniversary of the Moon landing and the 100th anniversary of the solar eclipse that confirmed Einstein's General Theory of Relativity. Sessions included the SLOAN Digital Sky Survey and looking at the accuracy, or not, of physics in space movies. Teachers travelled on to Dunfermline for workshops at SSERC on topics including: practical work, diagnostic questions, using the BBC micro:bit and experiments with PASCO Smart Carts. Look out for the 2020 event!

A conference for all who teach physics

Around 100 people gathered at the second North West Conference at Daresbury Laboratory in June. The day began with Jodrell Bank's Prof Tim O'Brien talking about *One Giant Leap: Jodrell Bank and the race to the Moon*. He mentioned Jodrell Bank's application as a UNESCO World Heritage Site – 10 days later, the news headlines confirmed it had been successful. After the lecture teachers attended workshops including rocket launchers, Van der Graafs, Daresbury Labs Tours, maths for physics and rope and pizza electricity models. Organiser IOP coach Andrea Fesmer said: "Already looking forward to next year's meeting!"

IOP

There is a chance we will be able to travel through time

This article by theoretical physicist, author, broadcaster and IOP council member Jim Al-Khalili first appeared in the Metro newspaper in June. We reproduce it with his kind permission.

It's everyone's favourite science question: is time travel really possible? There have been hundreds of movies and TV series that have explored this – some more intelligently than others – and there's always plenty of science-sounding jargon bandied about, like wormholes and higher dimensions and singularities and parallel realities.

But what does proper physics have to say on the matter? This is something I have studied over the past three decades. My first book, Black Holes, Wormholes and Time Machines, based on my Institute of Physics lectures, was published exactly 20 years ago.

There's a simple first question: Do the laws of physics allow for the possibility of time travel?

Not only do we know time travel to be possible, but that it is routinely demonstrated by experiments, albeit on a tiny scale. But travelling through time depends on whether we want to get to the future or the past because one is easier than the other. Isaac Newton believed that time was something that we have no control over – that it goes by at a constant rate, relentlessly ticking by the seconds, minutes, hours and years everywhere in the Universe at the same rate.

Then, in 1905, Einstein published his theory of relativity and brought about a scientific revolution. He showed that time is not absolute or independent of us but can be stretched and squeezed depending on how fast we are moving. In fact, by travelling close to the speed of light you can slow time down so that when you stop, less time has gone by for you than in the outside world and you will find yourself, quite literally, in the future.

Another way of getting to the future is predicted by Einstein's theory of gravity (we physicists call it General Relativity), which he completed in 1915, which showed that gravity also slows down the passage of time. So, time runs slower at sea-level than it does on top of a mountain, where it would in turn run more slowly than out in space – basically the stronger the pull of gravity (in this case the closer you are to the centre of the Earth, the slower clocks will tick).

The effect of Earth's gravity on time is very tiny so not that interesting. But if you could find yourself a black hole and orbit around it a few times (while being careful you don't get sucked in), its incredibly strong gravitational field would dramatically slow your time down. When you return to Earth, everyone will comment on how young you look considering the many Earth years you have been away.

Time travel into the past, on the other hand, turns out to be much trickier. But General Relativity – which is still our best theory on the nature of time – doesn't completely rule it out. It states that spacetime can be curved around to create what's called a closed time-like curve, which is a bit like a 'loop-the-loop' on a rollercoaster that takes you through both space and time back to the point you started, but before you left.

So, if time travel to the future is possible and time travel to the past is, while difficult, not yet ruled out, what are we waiting for? Why haven't we built a time machine yet? Is there something we're not understanding about the nature of time?

Well, very possibly. One problem was famously highlighted by Stephen Hawking who asked why, if time travel to the past were possible, we haven't been visited by time travellers from the future yet. After all, our time is, to them, in the past. If future generations ever succeed in building a time machine, then surely there will be some who would wish to visit the early 21st century.

Of course, it may be that time travellers from the future are indeed among us but simply choose to keep a low profile, or simply don't fancy a package tour to 2019. It turns out that this issue is easy to resolve. If we ever succeed in building a time machine, it turns out that it would only take us as far back as the moment it was switched on. So, the reason we don't see time travellers from the future is because time machines have not been invented yet.

However, there are many other really mind-boggling paradoxes that time travel throws up. The most famous one was explored in the film, *Back to the Future*. What if you were to go back in time and prevent your parents from ever meeting? Do you suddenly pop out of existence because you were never born? And if you were never born, you would never have grown up to become a meddling time traveller, so your parents will have met after all, and you were born, in which case you do travel back in time and prevent your birth... and so on.

The only sure way of resolving this paradox is if there exist parallel universes. This is an idea that may not be so crazy as it sounds and physicists are currently researching the idea. If such parallel dimensions are real, then time travel unavoidably slides the traveller into a parallel world in which he or she is able to mess with the past without it affecting them. So, stopping your parents from meeting in a parallel universe just means you will never be born in that universe.

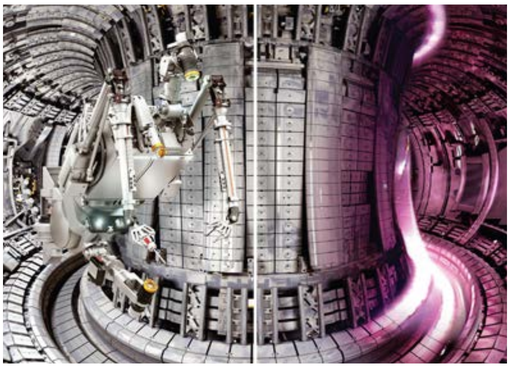
If I were a betting man I would say that time travel to the past will one day be shown to be impossible, even in theory. Getting to the future, on the other hand, just requires building a fast-enough spaceship to get you to the nearest blackhole. Beware though that if you reach the future, there may be no coming back if you decide you don't like it there.

Receive a signed copy of Jim Al-Khalili's new book

Sunfall is Jim Al-Khalili's first novel. It's a futuristic thriller about an end-of-the-world event that could actually happen, bringing together cutting-edge science with rip-roaring race-against-time storytelling.

For a chance to get a signed copy, enter your details at bit.ly/CPsunfall and we will pull names out of a hat on 30 September!

Bringing star power to the classroom


EUROfusion

The Joint European Torus (JET) at Culham Centre for Fusion Energy, is the world's largest and most powerful tokamak

The fascinating quest to harness the power of the stars – nuclear fusion – here on Earth for cleaner energy is the subject of a new education resources website for teachers.

How do you heat plasma to ten times the temperature of the Sun? Or design robots that can go into nuclear reactors? And what are the advantages and disadvantages of different energy sources? These topics and many more are covered on the website, which shows how science concepts taught in schools are applied to a major energy research project.

The website has been launched by The Learning Partnership, the people behind the Bloodhound 'Race To The Line' competition, in association with the UK's national fusion lab, the UK Atomic Energy Authority.

The fusion education channel has free teaching aids to explore the science of how fusion works, and the physics and engineering challenges of building fusion reactors that can one day power the grid.

These include classroom activities, fact cards, presentations and virtual tours of fusion experiments. There's also a section with profiles of people working in fusion research, showing examples of career pathways into STEM professions.

To access the resources go to bit.ly/CPukaea.

Massive definitions and weighty issues

Working with The National Physical Laboratory on updating a schools poster about mass reminded me the process is not straightforward. Professor Peter Main is Head of the Department of Physics at King College London and chairs the IOP Glossary Group

Weight and mass are terms that your students will have been using interchangeably in casual everyday conversations for most of their lives. It falls to you to teach them to use them as a physicist should.

The problem is that defining them is not straightforward.

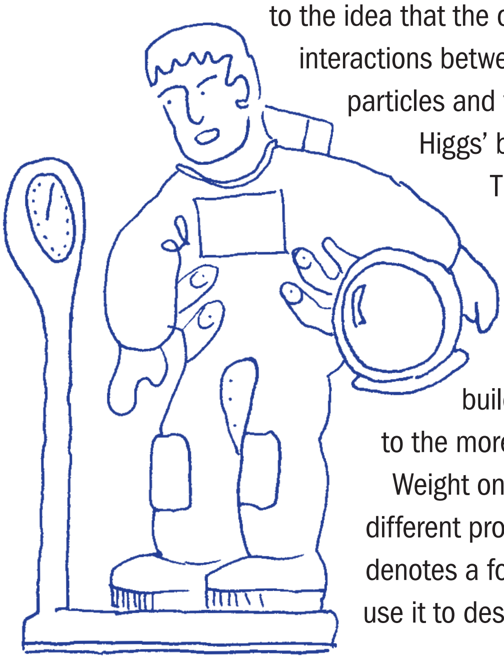
When students first encounter mass, it is often described as the quantity of stuff in an object, essentially the number of electrons, protons and neutrons. But we then have the question of what constitutes the mass of those particles? This question can be dodged and, as students progress, the idea of defining mass as inertia emerges, via $F=ma$, provided there is an independent definition of force. Gravitational mass is also introduced around this time. The problem is that there is absolutely no reason why these two masses should be the same. A compromise is to define both the inertial and gravitational masses via their respective forces and simply to say that more advanced physics explains why they are the same.

This isn't a question simply of defining the word 'mass': there is a fundamental and unanswered question in the physics itself.

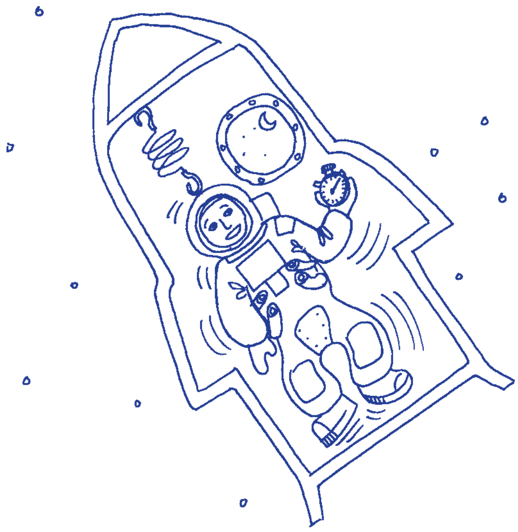
At the next level, we reach $E=mc^2$, so mass and energy are actually the same thing, leading to the idea that the origin of mass lies in the interactions between particles or between particles and fields. And onwards to the Higgs' boson.

The simplistic definition of mass as the amount of stuff in an object is not incorrect. Eventually, successive definitions will build upon each other, leading to the more complete understanding.

Weight on the other hand, is a different problem. In physics, weight denotes a force. But, some physicists use it to describe the gravitational force near the Earth's surface, while others use it to describe the upward contact force from the surface. This difference becomes problematic when describing objects that are accelerating. Is a floating astronaut in an orbiting space station truly weightless, as there is no contact force, or are they only apparently weightless because there is a gravitational force? What about the Moon? Should we be calling the gravitational pull of the Earth on the Moon the Moon's weight?



Measuring your gravitational mass on earth



Measuring your inertial mass in deep space

In the UK, weight usually refers to the gravitational force the Earth exerts on an object. But, there is always an alternative term to weight, which is unambiguous and universal - whether that's the gravitational, contact or any other force. It makes one wonder why the term weight is in the school curriculum at all; perhaps it is only so examiners can ask students to show that they can distinguish between mass and weight? Maybe physics needs to lose weight altogether.

Find out more: IOPSpark has three student misconceptions on this subject at spark.iop.org/mass-misconceptions.

Read *Massive misconceptions and weighty issues* on p8 of *Stories from physics: forces and motion.*

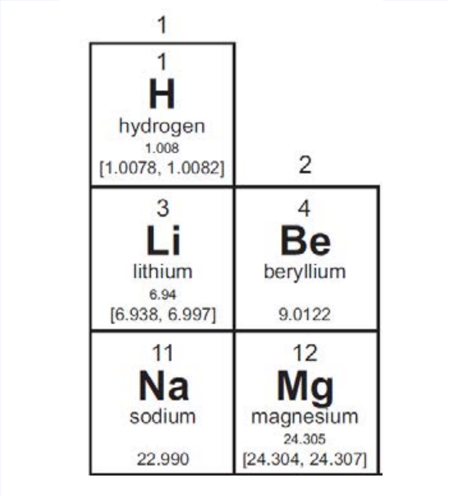
Pull out and keep

The periodic table in physics

The International Year of the periodic table marks 150 years since Dmitri Mendeleev ordered the elements which led to the modern periodic table.

The periodic table is fundamental to chemistry, helping predict how elements will interact and what properties they will display. In physics, the periodic table is about the nuclei, helping us to understand how they formed and where we might find – or create – new ones.

Physicist Ernest Rutherford's alpha scattering experiment in 1911 was a turning point in physics. It was the beginning of our understanding that atoms are mostly empty space, with tiny heavy nuclei. While it is not possible to reproduce the experiment in a school laboratory, it is well worth demonstrating how it was carried out using analogies. This pull-out includes three activities to help you do this – and to teach students that nuclei are SPAM: small, positive and massive!

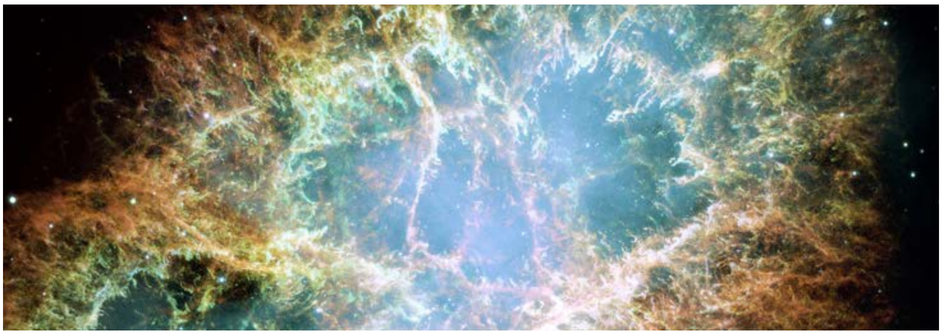


1	2
1 **H** hydrogen 1.008 [1.0078, 1.0082]	
3 **Li** lithium 6.94 [6.938, 6.997]	4 **Be** beryllium 9.0122
11 **Na** sodium 22.990	12 **Mg** magnesium 24.305 [24.304, 24.307]

The latest release of the periodic table (1 Dec 2018) includes the most recent updates released in June 2018 by the IUPAC Commission on Isotopic Abundances and Atomic Weights

What has physics done for the periodic table?

by Dr Ben Still, physics teacher and author of 'The Secret Life of the Periodic Table'



NASA and STScI

The Crab Nebula: a remnant of a supernova in which heavy elements such as uranium were created.

Physics has played a major role in the discovery of many chemical elements. From Rutherford's Alpha Scattering experiments, which established the nuclear model of the atom, allowing the periodic table to be organised, to contemporary work to discover the super heavy transuranium elements.

Uranium, element 92, is the heaviest known element to be found naturally on Earth today. Unlike other elements it does not have a stable isotope so every single form of Uranium is radioactive. However, the half-life of Uranium-238 in particular is 4.5 billion years – the age of the Earth – ensuring Uranium has survived the billions of years since it was first created in an explosive Supernova death of a supermassive star. This same star made all of the elements for the planets in our solar system and the left-over hydrogen and helium which formed our Sun.

No element 93 and above has an isotope with a long enough half-life that an appreciable amount survived naturally. Instead, physicists create these elements under high energy conditions to fuse nuclei together.

Those elements immediately after Uranium were first produced in the development and explosion of Plutonium and Uranium-based atomic bombs as part of the Manhattan Project. Einsteinium and Fermium were created in hydrogen or H-bombs which used nuclear fusion to produce a more devastating explosion.

Elements 101-118 were discovered in a very different way, in particle accelerators around the world. From the 1950s, these accelerators began slamming protons into one another, discovering many new and exotic sub-atomic particles. But they were also put to use accelerating large nuclei of heavy atoms. When these heavy nuclei smashed into stationary targets made of other elements, they hit with such a force that a handful of them fused together to form heavier nuclei.

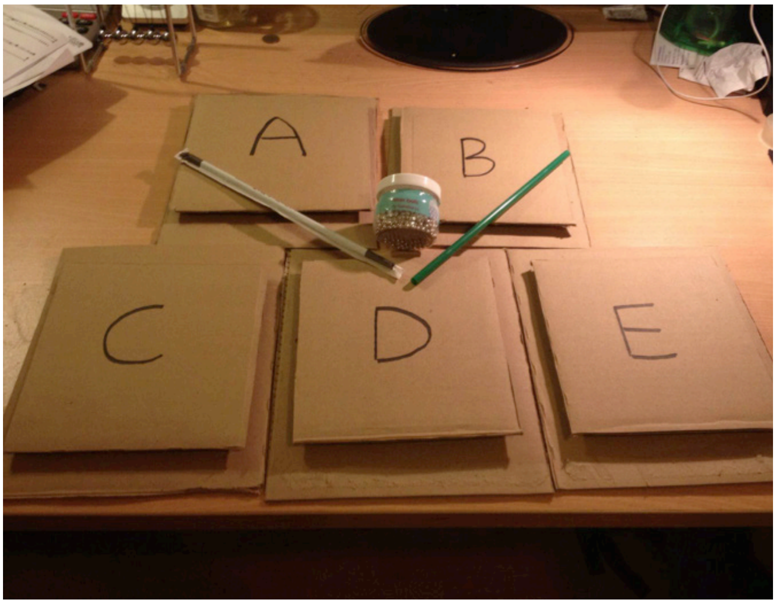
Each successive heavier element contains a fragile nucleus with shorter and shorter half-lives. A sample of element 118 Oganesson will halve in number in just 0.89 milliseconds.

Right now, the challenge may not be producing new elements but confidently identifying that they are there before they are gone.

- We have lots of teaching resources in the IOPSpark Model of the Atom collection at spark.iop.org/collections/model-atom.
- The Royal Society of Chemistry has a history and teaching resources at www.rsc.org/periodic-table.
- More about the International Year of the periodic table at iypt2019.org.

Activity 1: Mystery shapes game

This activity can help students understand how the nuclear model of the atom came to be. They roll ball bearings towards hidden objects and try to infer from the deflections what these mystery shapes are. This introduces them to the way that Rutherford and his colleagues were working to probe the structure of the atom, trying to decipher structures that they could not visibly see.



Equipment required per demonstration or group of students

- 10 ball bearings
- 2 straws
- 5 sheets of A2 paper
- A set of mystery shapes (cut five shapes such as square, rhombus, circle, hexagon, rectangle and a star from polystyrene mats such as ceiling tiles, stick each to a sheet of A4 cardboard, put glue on top of each shape and stick a smaller sheet of cardboard on top to make a sandwich. Label them A – E).

Discussion

The paths of the ball bearings indicate the shape each cardboard sandwich contains. Ask students to discuss in groups. Encourage them to consider the difficulties in resolving the shapes, what the ball bearings and shapes represents and limitations of the model.

Useful prompts:

Was the speed of the ball bearings a factor in determining the shapes? How does this relate to the alpha particles in the scattering experiment? Compare what you have just done with what Rutherford was doing. What is similar? And what is different?

Instructions

1. Divide the class into five groups. Give each group one of the cardboard sandwiches, a few ball bearings, straws and five sheets of A2 paper.
2. Display the shapes on the board and explain that they will be given three minutes per shape to determine which one it is.
3. Students roll ball bearings down through the straws towards the shape from all four sides. They should record the paths of the balls passing through and bouncing off the shapes by drawing them on the A2 paper (not on the cardboard). They should not look in between the sandwich!
4. When the three minutes is up, repeat the above steps until each group has worked with all five mystery shapes.

For more information:

There are some nice simulations by PhET at phet.colorado.edu/en/simulation/rutherford-scattering and The Particle Adventure at particleadventure.org

"All models are wrong, but some are useful"

As with all models in physics, it is important to discuss where the analogy ends:

- The models will produce far more deflections than Rutherford's original experiment: just one in 8,000 particles deflected through large angles.
- Students are producing deflections as a result of mechanical collisions: Rutherford's deflections were caused by electrostatic repulsion (Coulomb repulsion).
- In the original experiments, sheets of mica were inserted between the source and the gold foil to slow the alpha

Activity 2 : Card model for alpha particle scattering

Students simulate what happened in Rutherford's original experiment by rolling model alpha particles towards model nuclei.

Equipment required per demonstration or group of students

- Tray (could be an apparatus tray) to stop the beads getting lost
- Beads or ball bearings – two different colours to represent gold nuclei and alpha particles
- Thin card or paper template folded to fit tray (see figures 1 and 2)
- Blu tack (or similar) to secure model gold nuclei to the paper template
- Small plastic cup or beaker filled with beads representing model alpha particles

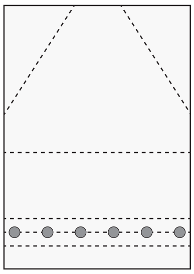


Figure 1

Discussion

In this model, the gold beads represent a row of nuclei in the gold foil. The paper template forms a ramp that the model alpha particles (purple beads) can be poured down: this represents firing the alpha particles from a source. The template can also be folded to give a potential hill at the point where the nuclei are positioned.

Students should observe the majority of their alpha particles go straight through to the end of the tray. But a number will be deflected through large angles and remain on the other side of the nuclei. If they space out the nuclei more widely, more alpha particles will go through. If they add more nuclei, more alpha particles are deflected. To get a full-on deflection, the alpha particle needs to hit the nucleus head-on. This model can be used to show that the atom is mainly empty space with the mass concentrated at the centre.

There are more deflections through large angles if the ramp is lower as the particles move more slowly. An increased interaction time means that a particle is more likely to be deflected through a large angle and represents the Coulomb repulsion of the alpha particle by the positively charged nucleus.

(quote from George Box, statistician)

particles. In activity 2, speed is controlled by tilting the ramp.

- Clearly these models are not to scale. Alpha particles are ten times smaller than gold nuclei – the diameter of an alpha particle is 10^{-15} m compared to 10^{-14} m for a gold nucleus, which in turn is 10,000 times smaller than the diameter of the whole gold atom.

Read Marsden & Geiger's 1913 paper *The Laws of Deflexion of Particles Through Large Angles* at bit.ly/CPmarsden.

Instructions

1. Fold the thin card or paper along the dotted lines into the shape shown (figures 1 and 2).
2. Use blu tack to fix the nucleus beads in place.
3. Lift the end of the ramp and pour the alpha particle beads down the ramp.
4. Note the angle of deflection of the alpha particles (figure 3).
5. Observe the effects of changing the distance between the model nuclei.
6. Tilt the ramp at different angles to change the speed of the alpha particles.
7. Observe the effects of adding more rows of nuclei.

Figure 2

Figure 3

Extension

After this, students may want to examine individual collisions in more detail.

To create the model:

- Print a 360° protractor onto a sheet of paper.
- Cut out protractor and a rectangular strip from the paper
- Set up as in figure 4 by blu-tacking a bead to the centre of the protractor.

Figure 4

Lift the end of the ramp and roll the alpha particle beads towards the nucleus. Note the angle of deflection of the alpha particle. Observe what happens when the size of the nucleus is changed. Observe what happens when the nucleus is positioned off centre. Tilt the ramp at different angles to change the speed of the alpha particles.

Another fun analogue is to use a wine glass.

See the YouTube video from the Perimeter Institute at bit.ly/CPwineglass

Activity 3: Rutherford Alpha Scattering: true or false cards

1

Alpha particles are helium atoms

2

Alpha particles are emitted by large unstable nuclei

3

Alpha particles are weakly ionising

4

Alpha particles have a range of a few centimetres in air

5

Alpha particles can be deflected by electric fields but not magnetic fields

6

Alpha particles are made up of two protons and two neutrons

7

In Rutherford’s alpha particle scattering experiment, the alpha particles were counted using flashes of light emitted by a fluorescent screen

8

In Rutherford’s alpha particle scattering experiment, a thick sheet of gold foil was used as a target

9

In Rutherford’s alpha particle scattering experiment, the alpha particles travelled through air before hitting the gold target

10

In Rutherford’s alpha particle scattering experiment, most of the alpha particles fired at the gold foil bounced back

11

In the Plum Pudding model, atoms are made up of a sphere of negative charge with protons stuck into it

12

In the nuclear model of the atom, most of the mass is concentrated in the centre

Teacher notes

Please photocopy this page, cut out and laminate a set of cards for each group of students. Ask them to sort the statements into true and false. Feel free to add your own cards!

Cards 2, 4, 6, 7 and 12 are true. Cards 1, 3, 5, 8, 9, 10 and 11 are false.

More on Rutherford’s Alpha Scattering experiments at spark.iop.org/rutherfords-alpha-scattering-experiment

Look after your detectors

Experimental evidence for the nucleus was first collected by Ernest Marsden and Hans Geiger. Their experiment famously needed an observer to notice tiny points of light, called scintillations, produced by the impact of an alpha particle. The delicate observation required for this work required sharp eyesight – Marsden recalls being instructed by Geiger not to put his head out of the window when travelling by train, not due to safety concerns, but in case a smoke particle damaged his vision and his ability to act as a human alpha particle detector.

The woman who split the atom

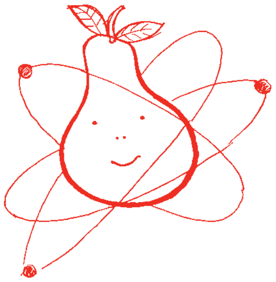
Lise Meitner, who many people believe should have been awarded a Nobel Prize for her work on nuclear fission, was involved in a dramatic escape from Nazi Germany. During Hitler's rise to power, Meitner was working in Berlin. Unlike other Jewish scientists who were forced to resign their academic posts, Meitner had Austrian citizenship and so was able to carry on working till 1938. Eventually, feeling increasingly threatened, she escaped with the help of academic colleagues. Bohr invited her to lecture in Copenhagen, all expenses paid, but Meitner was refused travel documents. Ultimately, with the help of Otto Hahn and Dirk Coster, with whom she communicated in coded telegrams, she escaped to the Netherlands. Later, Wolfgang Pauli sent Coster a telegram: 'You have made yourself as famous for the abduction of Lise Meitner as for [the discovery of] hafnium!'

Warring scientists

Geiger and Marsden served on opposite sides of the Western front during the First World War, Geiger as a German artillery officer and Marsden in the sound-ranging section of the British Royal Signals. During the fighting, Geiger managed to communicate with Marsden by sending a letter using Niels Bohr in Copenhagen as an intermediary.

The nucleus that's gone pear shaped

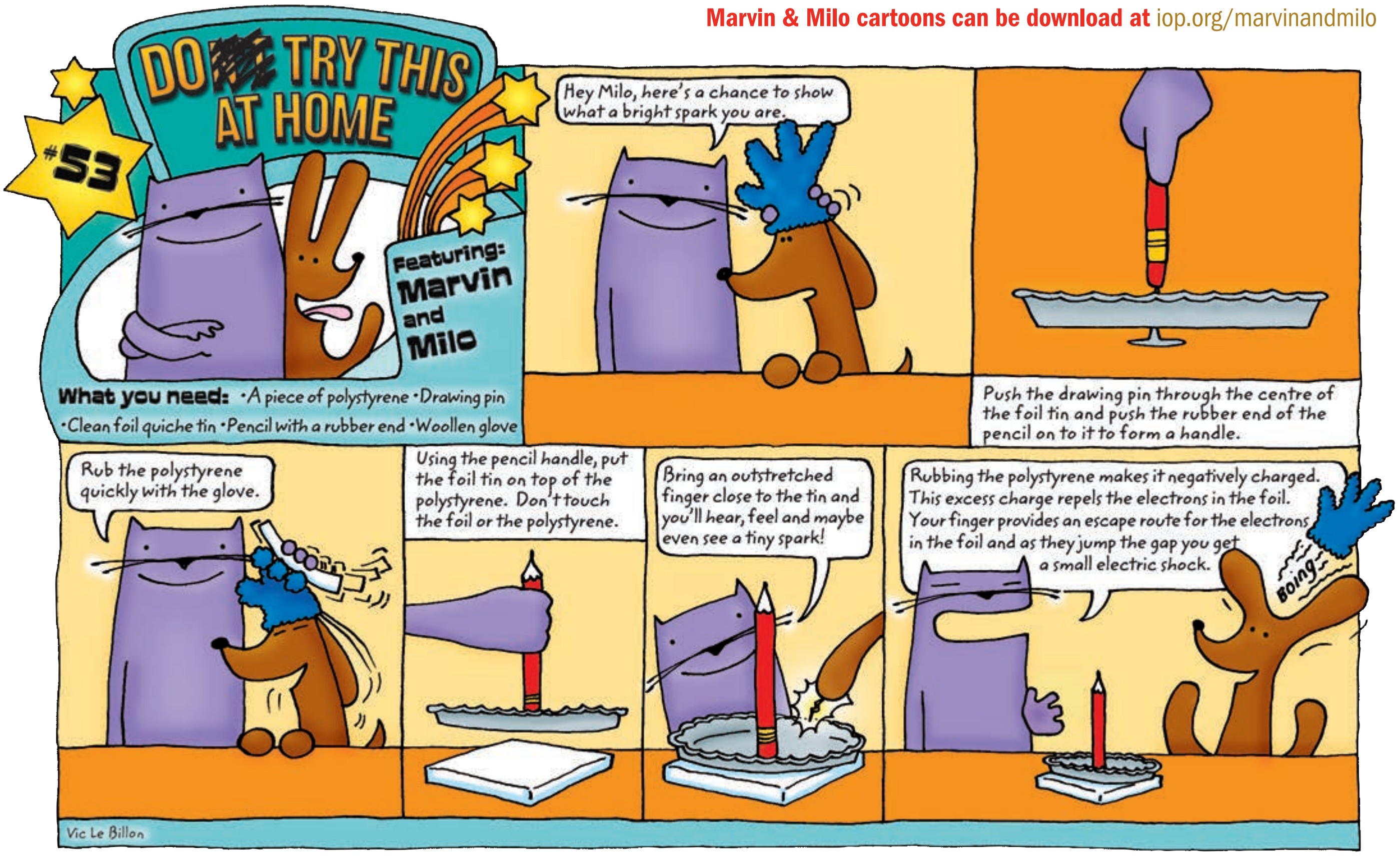
The majority of nuclei are either spherical or shaped like a rugby ball. For many decades, nuclear physicists had predicted that the nucleus of barium-144 would take on an asymmetrical pear shape. But it wasn't until 2013 that a team at the REX-ISOLDE radioactive-beam facility at CERN provided strong evidence of the pear-shaped nuclei of radium-224 and radon-220. These heavy nuclei are created by colliding protons with uranium carbide, and are then accelerated and fired at targets of nickel, tin and cadmium. The radon and radium pass close to the nuclei in the target material, exciting the accelerated nuclei and causing them to emit gamma rays. Analysis of the emitted rays confirmed that the nuclei were pear-shaped.



Follow Richard's stories about physics on Twitter @RBrockPhysics

Quiche lightning

Marvin & Milo cartoons can be download at iop.org/marvinandmilo



Physics*education*

Physics Education is our international journal for physics teaching research. Affiliated Schools have access to the journal online at iopscience.org/physed. Email us at affiliation@iop.org if you need a reminder of your login details.

There are over 50 years of papers in the Physics Education archive.
On this page, editor Gary Williams picks his favourites on the theme of atoms and nuclei.

Atoms in the secondary school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The green colour of our lawns is a direct consequence of a slightly broken molecular symmetry.

Although they date from 1976, two papers from George Marx are a good starting point for refreshing your physics knowledge about atoms: *Atoms in the secondary school: Part I & 2.*

Starting with Dalton and moving quickly on to the Uncertainty Principle, Quantum numbers, the Exclusion Principle, electron orbitals, bonding, symmetry and molecules, Marx gives an excellent and concise summary of everything you need to know.

He also includes some gems that may not be familiar to you, like explaining why grass is green: "a direct consequence of a slightly broken molecular symmetry".

Read the paper at bit.ly/PEDatoms1 and bit.ly/PEDatoms2 (September 1976). Written by George Marx, a distinguished theoretical physicist and physics educator

The scattering of particles

This paper describes a relatively simple apparatus for explaining scattering and then describes a process by which order of magnitude results may be obtained for the size of molecules. This would be suited to 16-18 year old students and looks a more challenging practical than putting a drop of oil on water.

Read the paper at bit.ly/PEDbolton (1968). Written by W Bolton, High Wycombe College of Technology and Art

Marbles: a means of introducing students to scattering concepts

This might provide students with more understanding of the statistics before proceeding with the ideas in the former paper. It introduces concepts of short-range and long-range scattering, indirect measurements and probabilistic models.

Read the paper at bit.ly/PEDmarbles (January 2008). Written by KM Bender at al from the Institute for Teaching and Learning, The University of Akron

How do we know what is 'inside the atom'? Simulating scattering experiments in the classroom

Very accessible and easy to implement in the classroom. Includes a Lego-based activity!

Read the paper at bit.ly/PEDlegoatoms (June 2017). Written by ES Cunningham, particle and nuclear outreach officer for Science and Technology Facilities Council

'Rutherford's experiment' on alpha particles scattering: the experiment that never was

The so-called Rutherford's experiment, as it is outlined in many physics textbooks, is an example of the flaws in how we teach one of the decisive events of modern physics: the discovery that the atom has a nucleus. This paper shows that this alleged experiment is a very approximate and very partial synthesis of a series of different particle scattering experiments, starting with that carried out by Rutherford in 1906 and ending with Geiger and Marsden's 1913 experiments.

Read the paper at bit.ly/PEDruther (May 2018). Matteo Leone is at the University of Turin

The Billotron

Show your students the video of the Billotron. It's unlikely you'll ever have the time or inclination to make one or even its smaller sibling the Billotrino, but the video explains exactly what the analogy is supposed to show in what might be the world's most expensive version of these physical models.

Read the paper at bit.ly/PEDbillotron (June 2015) The Billotron was funded through the 'Têtes chercheuses' prize given by 'La Fondation Musée Schlumberger' and 'Relais d'Sciences'

Find out more

Can the periodic table be extended indefinitely?

The heaviest naturally occurring element is uranium with Z = 92. Transuranic elements up to Z = 118 have now been synthesised. Author Rick Marshall asks, "Is there an upper limit to the number of distinct elements that can exist and could all these new elements actually form atoms?" He discusses the 'magic numbers' of neutrons and protons that result in more stable nuclei and asks whether there is actually an upper limit for the periodic table – a good way to get your more advanced students thinking.

Read the paper at bit.ly/PEDtransuranic (May 2014) Rick Marshall has been an academic physicist, head of physics at a secondary school and a curriculum developer.

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Physics Education is our international journal for physics teaching research. Affiliated Schools have access to the journal online at iopscience.org/physed. Email us at affiliation@iop.org if you need a reminder of your login details.

**Physics Education publishes new content on an ongoing basis.
On this page, editor Gary Williams highlights some recent papers and articles.**

Demonstrating mirages in air in the lab

Over the summer students will no doubt have seen ‘mirages’ caused by the infra-red from the sun falling on dark roads as they absorb and re-emit radiation and cause heating of the air just above the road’s surface. Explanations of this effect can be a little tricky but this relatively simple demonstration allows students to see what’s happening very easily. All that’s needed is a small hotplate and a line drawing laser as used for DIY; but the authors suggest how to do this demonstration with even simpler apparatus than that.

Read the paper at bit.ly/PEDmirage. (July 2019) Written by Dragia Ivanov and Stefan Nikolov of Plovdiv University

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Mirages are a naturally occurring optical illusion - create one in your classroom!

You could argue...

Students don’t always get a very genuine experience of science, perhaps because they may only come across ‘verification’ experiments, where everyone already knows the answer. They may never do a real experiment where they need to show that the link between data and hypothesis is statistically higher than for any competing hypothesis. A series of activities are suggested in the paper *Introducing argumentation in inquiry—a combination of five exemplary activities* that looks to take students understanding further. All five activities are easy to implement in the classroom and could be used with a variety of age ranges.

Read the paper at bit.ly/PEDargue. (July 2019). Written by physics education researchers Freek Pols, Peter Dekkers and Marc de Vries

...or you could just go camping

Trevor and Lara Hill published a paper on sleeping bags in 2017. Trevor has followed this up with work on sleeping mats. As the author says: “For a sleeping bag to perform to the manufacturer’s specification the bag must be combined with a high-quality sleeping mat and thin foam mats and hollow airbeds may be false economy.” If you’re a keen camper, or have students who are, then there’s some sound, evidenced advice in this paper, with experiments that can be easily replicated.

Read the papers at bit.ly/PEDcampbags (May 2017) and bit.ly/PEDcampmats (May 2019). Trevor is a retired physics teacher, Lara is his granddaughter.

Deep thought

If you’re interested in writing your own scheme of work, take inspiration from *Decisions in curriculum development – a personal view* from Jon Ogborn from 1978. Consider this from the concluding paragraphs: “Education, I said, is a practical art... What I do think is that the practical art of designing teaching is complicated, needs all our skill in a great diversity of areas and can, like other arts, give deep pleasure to all those involved.” The paper includes useful insights into the thought processes behind writing a course, but thankfully we don’t refer to all physics students as “he” these days!

Read the paper at bit.ly/PEDcurriculum. Jon Ogborn is emeritus professor in physics education

More recent articles in Physics Education

The elastic ballistic pendulum
bit.ly/PEDballistic

Five misconceptions about black holes
bit.ly/PEDblackholes

The impact of a hammer and a nail
bit.ly/PEDhammer

What happens next?

Two candles, one long and one short, are lit and covered with a tall jar. As the oxygen is used and carbon dioxide is produced we would expect the candles to be extinguished. But do the candles go out together or does one go out first? And, if the latter, which candle will be extinguished first and why?

What happens next? is a regular Physics Education feature. Find the answer to this question – and view the archive – at bit.ly/PEDwhatnext

professional practice group

The IOP Professional Practice Group is a team of experienced IOP coaches who work with teachers who lead physics CPD. To find your nearest contact, email rachel.hartley@iop.org

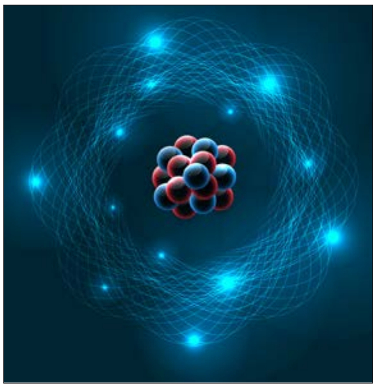
Teaching atomic structure

Many students will have already covered atomic structure in chemistry. Although this may seem a time saver, it can cause confusion. Students have been using their 'solar system' diagrams for quite a while in chemistry. We're often asked why we bother with Thomson's plum pudding model "because it's wrong".

Dalton's model of an indivisible atom was very good for the properties of solids, liquids and gases. Tweaking it to propose the plum pudding model when the electron was discovered made sense, especially as it was backed up by alpha and beta scattering experiments. It was accepted that these radiations passed through atoms as the plum pudding was not an impenetrable lump, so the model could explain a lot of chemical and physical phenomena. Students often think Geiger and Marsden's subsequent work was just a single experiment to test Thomson's model, rather than a carefully refined series. Our models evolve with each new discovery – science is often about making mistakes and learning from them.

Now that the Bohr atom is included at GCSE, it is a good idea to discuss how it is different from the Rutherford model. However care needs to be taken to ensure that beta and gamma emission are seen as nuclear processes, rather than being associated with the electrons around the nucleus.

As a final thought, we often advise teaching this topic after looking at the properties of ionising radiations and radioactive decay. Research has found that students can struggle with the atomic and sub-atomic level explanation of radioactive phenomena because their understanding of the particulate model of matter is not secure.



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Recommended reading:

Teaching about Radioactivity and Ionising Radiation: An Alternative Approach by Robin Millar et al bit.ly/PPGradio

Students' description of an atom: a phenomenographic analysis by Ridvan Ulal & Dean Zollman bit.ly/PPGatom

Rutherford's nuclear world by American Institute of Physics bit.ly/PPGruther

physicsworld

Stories from our magazine for the global physics community. Visit physicsworld.com

Battle of the elements

Which is your favourite element? And how about your students'?

To mark the International Year of the periodic table, Physics World journalists argued for their pick from the 118 known elements. The month-long battle pitched nine elements against each other on the Physics World Everyday Science blog and podcast. Voting took place via twitter.

In the first round, silicon beat gold and uranium. In the second, carbon saw off technetium and helium. The third round pitched iron, lithium and nitrogen against each other, with iron winning.

Readers and listeners also sent in their choices. John argued that argon should win as it is essential to the process for producing wine in his son's business. Mark went for seaborgium, named after the chemist who discovered iodine which was instrumental in his wife's cancer treatment. And Jo couldn't resist the excitement in her 1950's childhood when a thermometer broke and she could chase the spheres that spilled to the floor.

The final three elements, silicon, carbon and iron, were put to the vote on Twitter. It then went head to head with the winner of Chemistry World's Battle of the Elements.

We won't reveal the results here but you can find out the winner of the Physics World Battle of the Elements by listening to the podcast at bit.ly/PWbattle. To follow the Twitter battle against the chemists' choice, search for #battleofelements And let us know the winner of your school's Battle by emailing education@iop.org

Memorise the periodic table? No!

Originally published in Education in Chemistry as part of a series to support each evidence-based principle in the Education Endowment Foundation's *Improving Secondary Science* guidance. Written by Nikki Kaiser, a research lead and chemistry teacher in Norwich.

Read the full article and find more IYPT themed articles and resources on the Education in Chemistry website: bit.ly/eiciypt

The periodic table is the chemist's alphabet, and we need to be very familiar with it. By putting the elements together in various combinations, as we do when we spell words, we can build our dictionary, containing all the substances in the universe.

But just as you don't learn the dictionary from cover to cover, students don't need to memorise the order of the periodic table from left to right to use it effectively. I would argue that time in school should be focused on learning how and why the periodic table is put together as it is, rather than learning the elements' order off by heart.

That said, a good familiarity with it is important. Chemists need to know the symbols of common elements and have a feel for where they are located. But more importantly, they need to know what an element's location tells them about its properties.

It's important students memorise the order of elements in specific groups. For example, they'll learn that sodium is a reactive alkali metal, with one electron in its outer shell, but potassium is an even more reactive group one metal. They'll begin to remember where common elements like nitrogen, oxygen and carbon are located. But this is all learned in context. Remembering which elements are found within the same period is also useful, as is learning which elements are found within specific blocks.

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So I have nothing against memorising the periodic table per se. It's important to increase your familiarity and confidence as a chemist. But learning elements by rote is not an end in itself, and has limited utility in isolation. Until they really understand how to use it, students' precious time could be better spent elsewhere.

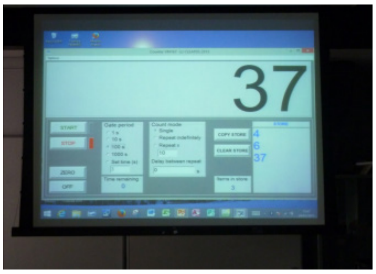
CLEAPSS is an advisory service supporting science and technology in schools. Its advice and guidance is recognised by Ofsted and the HSE for safe practice for practical work in schools. It has extensive resources for teachers and technicians. Most schools can access its website and resources through Local Authority subscriptions cleapss.org.uk

Guidance on managing, storing and handling radioactive materials and equipment

Following a deluge of very similar helpline calls and e-mails on the use, storage and management of radioactive sources in schools recently, we have put together a FAQ on the area. Please contact the helpline for clarification if needed at science.cleapss.org.uk/helpline, but we hope that this will answer a lot of the burning questions you may have. Find answers to questions such as:

- Why can't the technician be the Radiation Protection Supervisor (RPS)?
- Can we use the sources if the RPS is off site?
- How often does the RPS need to be re-trained?
- What is a Radiation Protection Adviser (RPA) and why do we need one? If we are CLEAPSS members, does this mean we have RPA cover?
- Can pregnant teachers/technicians/students use the sources?

Answers and lots more information available at bit.ly/cleapssRPS



CLEAPSS

Make your own Geiger-Mueller counter

DIY Counter Unit

We have recently produced instructions on how to make a Geiger-Mueller counter unit for displaying the counts from a GM tube onto a screen by data projector. The new unit offers great advantages, in that the circuitry which powers the tube is embedded within the unit and students can see the counts clearly on the projector screen as opposed to a small display on a counter unit. This is not a difficult project, but it is not advisable for those who lack experience in electronics and soldering.

Instructions at bit.ly/cleapssGM

School Grants Scheme

The Schools Grants Scheme is run jointly by Institute of Physics, Institution of Engineering (IET) and the Science and Technology Facilities Council (STFC). Schools, colleges and home school groups in the UK and Ireland can apply for a grant of up to £600 for a physics or engineering related project.

We are keen to support innovative projects and activities in the following areas:

- particle physics
- astronomy
- space and nuclear physics
- energy
- transport
- information and communications
- design and promotion
- built environment.

There are three deadlines for applications each year: 1 February, 1 June and 1 November.

If you would like to apply for a grant then please visit our website or email us at schoolgrants@iop.org.

IOP Institute of Physics

iop.org/schoolgrants

Schools and Colleges Affiliation Scheme

If you are reading a paper copy of *Classroom Physics*, it is probably because your institution is a member of the IOP Affiliation Scheme.

In addition to Classroom Physics four times a year, here is a reminder of what else you receive:

- *Physics World* magazine monthly, keeping you in touch with developments in physics as well as providing inspiration for your students
- Online access to *Physics Education*, our international journal for physics education research, containing articles about teaching physics, news, teaching tips and reviews and software (if you don't currently have a log-in, please email affiliation@iop.org)
- Resources including posters and careers materials

If your school/college is not currently affiliated and would like to become part of the scheme, then please email us at affiliation@iop.org or call +44 (0) 20 7470 4832.

IOP Institute of Physics

iop.org/affiliation

I'm a Scientist Get me out of here

Returning for two weeks from Monday 11 - Friday 22 November

Big Data Zone (IOP)
We are living in the era of computers and Big Data. An almost unimaginable amount of information about us and the world is collected every second. What on earth do we do with it all? Scientists in the Big Data Zone will all be using computers, data and algorithms in a range of areas and industries, from astronomy and particle physics, to medical physics and meteorology.

Elements Zone (Royal Society of Chemistry)
To mark the 150th anniversary of the Mendeleev periodic table, the Elements Zone will feature six chemists who are making use of elements in their research or work in industry.

Other physics-based zones include The Electromagnetic Zone and Nuclear Zone.

Apply now to take part!
If you're already on our lists, please check your email inbox.
If you're new to our events,apply by Monday 23 September at imascientist.org.uk/teachers.

CHARTERHOUSE

Free physics subject enhancement course 2019-20

Sat 9 Nov 2019	Motion
Sat 16 Nov 2019	Forces and Motion
Sat 30 Nov 2019	Energy
Sat 11 Jan 2020	Energy quantitative approach
Sat 18 Jan 2020	Electricity basics
Sat 25 Jan 2020	Electricity and Magnetism
Sat 1 Feb 2020	Gases, liquids and solids
Sat 8 Feb 2020	Waves and Sound
Sat 29 Feb 2020	Light
Sat 7 Mar 2020	Maths for GCSE physics

All courses 09.30 am - 11.30 am. Coffee is provided.

There is no charge for materials or course tuition but you must pay your own travel costs.

For more information email Steve Hearn:
sth@charterhouse.org.uk

To register email:
science@charterhouse.org.uk

Cracking news

The UK team enjoyed success at the International Physics Olympiad in Tel Aviv, Israel this summer. The five sixth-formers won three Silver and two Bronze medals. The week was topped off by winning first place out of 76 countries in the team safe-cracking competition.

This year 27,000 students in the UK participated in a BPhO competition, from Year 10 (an online physics quiz) to Year 13 (hard problems on A level physics). A new Year 10 online Astro Quiz for years 9 & 10 will take place Friday 8 – Friday 22 November 2019

Find out how students and teachers can become involved at www.BPhO.org.uk.

British Physics Olympiad

UK esero

ESERO-UK Secondary Space Conference

Teacher Q&A session with Tim Peake

25 September 2019 Newport, Wales

A limited number of places are still available

European Space Education Resource Office UK will be holding their annual teacher conference in September alongside the UK Space Conference. Participants will be able to engage in activities linked ESA's ExoMars mission, the celebration of the 50th anniversary of the First Manned Lunar Landing and the upcoming James Webb Space Telescope.

Attendees gain free access to the UK Space Conference.
The conferences will help you to understand how current space missions can provide an engaging context for teaching and you will be able to take part in practical activities which you can deliver in the classroom. You will also learn more about STEM careers in the rapidly growing UK space industry.

Register at bit.ly/CPesero19

Find a CPD event near you at talkphysics.org/events

Yes, the sun shone! Delegates at the 44th Northern Ireland Physics Teachers' Conference 2019 at the Armagh Planetarium in June

13th Annual East Midlands Network Day

21 September 2019

Uppingham School, Rutland LE15 9QE

Register at
bit.ly/IOPmidlands19

Frontiers of Physics

28 September 2019

Waterford Institute of Technology, Ireland

Register at
bit.ly/IOPfrontiers19

A Day for Everyone Teaching Physics (IOP and NUSTEM)

5 October 2019 9:30 am - 3:00 pm

University of Northumbria,
Newcastle-upon-Tyne NE1 8ST

Register at
bit.ly/CPnustem19

SPEED2019 (IOP and Isaac Physics)

5 October 2019 10 am - 4 pm

Netherhall School and Sixth Form Centre,
Cambridge CB1 8NN

Register at
talkphysics.org/events/speed2019

IOP Hull Regional Day

15th October 2019 9:30am – 4.15pm

University of Hull, Cottingham Rd,
Hull HU6 7RX

Register at
bit.ly/IOPhull19

IOP Regional day (Midlands)

18 November 2019

Shrewsbury Sixth Form College –
Welsh Bridge campus

Register at
education-midlands@iop.org

IOP London Physics CPD day

23 November 2019

Dulwich College, SE21 7LD

Register at
bit.ly/IOPlondonCPD19

Canterbury regional CPD day

7 March 2020 9.15 am - 4.15 pm

St. Anselm's RC School,
Canterbury CT1 3EN

Contact
Jessica.rowson@iop.org

Prepare to teach A-level Physics: a 6 day course (IOP and Ogden Trust)

9 Oct, 13 Nov 2019
26 Feb, 25 Mar, 6 May, 8 July 2020

Rugby High School, CV22 7RE

Participants are expected to commit to all six days.
Register with mighalls@rugbyhighschool.co.uk or contact Helen Pollard helen.pollard@iop.org

Bristol area physics CPD day

March 2020 (date to be confirmed)

Clifton College, Bristol

Contact
trevor.plant@iop.org

All events listed are funded by the IOP and free to attend unless otherwise stated.
All teachers of physics are welcome, whether or not you consider yourself a physicist!

Contact your IOP regional education manager to find out about CPD and CPD coaching opportunities near you:

Scotland
Stuart Farmer
stuart.farmer@iop.org

Ireland
Paul Nugent
paul.nugent@gmail.com

Wales
David Cunnah
david.cunnah@iop.org

England

Yorkshire and northeast
Jenny Search
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Northwest
Graham Perrin
education-northwest@iop.org

Midlands
Ian Horsewell
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London, East-Anglia and Kent
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