NPL

THE MEASURE OF ALL THINGS

OPEN HOUSE
Visitor Guide

Thursday 17 May 2018
from 2 pm to 8 pm

Welcome to the National Physical Laboratory

The Measure of All Things

We are delighted to welcome you to the National Physical Laboratory (NPL) and show you our world-class laboratories as well as giving you an insight into the amazing science that we do here.

NPL is the UK's National Measurement Institute. We're responsible for making sure that all measurements made in the UK can be traced back to agreed standards, ensuring consistency and reliability. Accurate measurements are important in so many fields; our research helps support scientific and commercial innovation, international trade, environmental protection, and health and wellbeing.

Measurement expertise is relevant to global challenges, such as climate change, curing diseases and supporting the latest communications technology. Our role in supporting trade, which we have been doing since 1902, has probably never been as important as we head towards exiting the EU.

Last year we re-launched NPL to align more closely with government priorities and industry needs. We are focused on advanced manufacturing, digital, energy and environment, and life sciences and health. We are dedicated to creating impact from science, engineering and technology, and making a real difference to companies and individuals. Our renewed focus will help accelerate UK industry for the next 100 years and beyond.

Our Open House coincides with World Metrology Day (metrology is the science of measurement), which falls on 20 May, and is particularly important this year. We are celebrating NPL's leading role in the international programme to review the standard units of measurements. The global metrology community anticipates that a revision to the SI units will be agreed in November 2018, and will impact on four of the base units, the kilogram, ampere, kelvin and mole. Supporting the constant evolution of standards and the need for ever more accurate measurements is an ongoing priority for NPL.

We hope you enjoy your time with us. Please ask our world-class scientists about what they do and find out how our pioneering work is helping to save lives, protect the environment and enable citizens to feel secure.

Dr Peter Thompson
Chief Executive Officer

What is NPL?

The National Physical Laboratory (NPL) is the UK's National Measurement Institute, providing the underpinning measurement capability for UK prosperity and quality of life. From new antibiotics and more effective cancer treatments, to unhackable quantum communications and superfast 5G, technological advances must be built on a foundation of reliable measurement to succeed.

We are a world-leading research facility with over 500 scientists and engineers working in a wide range of fields to save lives, protect the environment and enable citizens to feel safe and secure, as well as to supporting international trade and innovation. As a national laboratory, our advice is always impartial and independent, meaning consumers, investors, policymakers and entrepreneurs can rely on the work we do.

We were originally based in Bushy House, Teddington. Since then we've grown to fill nearly 20 buildings on our Teddington campus, and also have sites in Huddersfield, Strathclyde, Surrey and at Wraysbury Reservoir.

www.npl.co.uk/about/what-is-npl

Follow us on social media

npldigital **@npl** **npldigital** **national physical laboratory**

#NPLOpenHouse

Our vision

Our vision is to be an exemplary National Laboratory that undertakes excellent science and engineering and uses this to deliver extraordinary impact for the UK.

NPL's focus areas for the future

Advanced Manufacturing

NPL focuses on growing the economic impact and competitiveness of UK manufacturing, by helping businesses big and small to harness the potential of the digitally-enabled supply chain and take advantage of new materials and processes, such as composites and additive manufacturing, to become more responsive, sustainable and efficient.

Energy and Environment

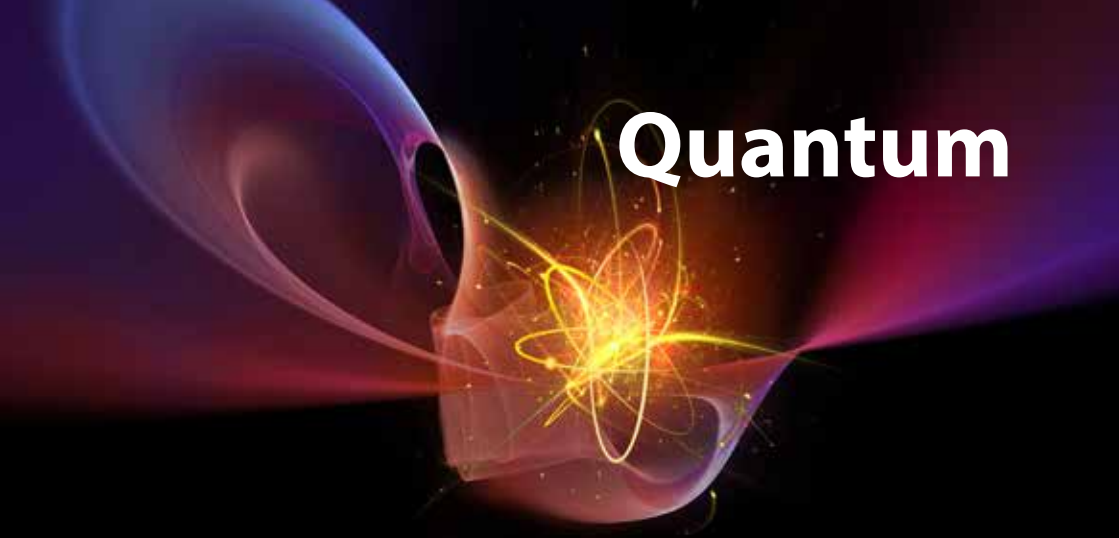
NPL is paving the way to a cleaner future, by supporting the decarbonisation of the energy sector, helping to transition our energy system so that it is smart, clean and resilient, helping businesses validate their innovative clean technologies, and providing confidence in data on the climate, greenhouse gas emissions and air pollution.

Digital

NPL is unlocking new digital opportunities, by testing and validating new technologies, such as quantum devices and 5G, to protect consumers and provide a competitive edge to industry; we are also transforming the way we collect, connect and comprehend data.

Life Sciences and Health

NPL is working to tackle some of the world's biggest health challenges, by standardising and improving diagnosis and treatment techniques to help all UK NHS hospitals provide world-class cancer care by 2020, and reducing attrition rates in drug development, as well as working on new therapies including novel antibiotics, to get them to patients more quickly.



Quantum

The Quantum Metrology Institute at NPL

Quantum science is the study of how light and atoms interact individually. A quantum of something is the smallest possible amount of light, energy or electricity. A lot of modern technology uses basic quantum science; the laser is a very good example. The challenge now is to use some of the more unusual aspects of quantum science to build new technologies.

The Quantum Metrology Institute (QMI) at NPL is an important partner in a government-supported programme across the country to develop new technologies based on quantum science. The programme includes laboratories such as NPL, many UK universities, and a wide range of UK industries from sectors including healthcare, security, construction, transport and finance. These new technologies have the potential to create new products and services, generate growth for the economy, new jobs and improved productivity for the UK.

NPL has a strong history in quantum technologies. The world's first working atomic clock used as a time standard was built at NPL in 1955. The atomic clock is a quantum device; it measures the frequency of light absorbed by an atom with extraordinary precision. We are already applying quantum technologies, including:

- delivering a precise time signal over fibre to the City for time-stamping of financial trades
- developing laser cavities for the UK Space Agency
- devising test methods for quantum communications for BT
- developing very sensitive magnetic field sensors for healthcare
- producing new devices for precise current, voltage and resistance standards
- ensuring the effectiveness of quantum computers

To explore our quantum labs and talk to members of our QMI team, look for this symbol on the map.

THE MEASURE OF ALL THINGS

What is the SI?

The International System of Units (SI) was founded in 1960. Since then its importance has grown as we have come to rely on advanced science and engineering, not just in manufacturing and trade but also in our everyday lives. For example, our ability to make clocks which accurately track time at the same rate underpins global positioning systems and the infrastructure of the internet. Similarly, our ability to undertake comparable measurements on different continents enables trade by allowing companies to source components from around the world and yet be confident that they will fit together.

How are the units of measurement defined?

Historically, systems of measurement have been developed in every civilisation. Originally, measurement units were defined by physical objects such the length of a standard bar, or the weight of standard object. And that is how systems of measurement – imperial and metric – operated until the second half of the twentieth century. However, it was appreciated that using unique artefacts to define measurement units was risky as they could easily be damaged through repeated use to create new copies or to check old copies.

Over the last 50 years, two insights have led us to seek a different way to define a standard quantity. The first insight was that it would be desirable to have definitions of the base units that did not rely on physical artefacts – ensuring there was no danger that the artefact could be lost or damaged. The second insight was that there appeared be a number of 'natural constants' which were more stable than the standard artefacts against which we measured them. Together these two ideas led to the concept of basing our system of measurement on these naturally constant quantities.

In 1968 the second was re-defined as the time for a specific number of oscillations of an atom of caesium-133. We consider that atoms of caesium-133 will always oscillate at the same frequency and so this frequency – the rate of 'ticking' of the clock – should remain perfectly stable throughout time. This insight, together with the development of 'atomic clocks' that could keep time from the oscillations of atoms, enabled a new era of ever more accurate time measurements. This led to the development of GPS and applications such as the internet, that no one could have foreseen.

In 1984 the metre was redefined as the distance travelled by light in a given time. This re-definition built on the work of Einstein, who led us to the understanding that the speed of light in a vacuum was a universal constant. This insight – together with the ability to measure distances using light – led to ever more accurate dimensional measurements.

In 2019 we will redefine the ampere and the kilogram. Additionally, the definitions of the kelvin (and the degree Celsius) and mole (the amount of substance) will also be changed. Although these changes are highly technical and are not expected to have any immediate consequences, they represent a profound change of perspective. From May 2019 the base units of the SI will be defined in terms of natural constants – the most stable things we have ever encountered.

As with the changes to the second and the metre, we cannot foresee the consequences of these re-definitions, but we expect them to form the foundations for decades of improved measurements.

What are the seven base units?

metre (m)  – length

kilogram (kg)  – mass

second (s)  – time

kelvin (K)  – temperature

ampere (A)  – electric current (the movement of electrical charge in a wire)

mole (mol)  – amount of a substance

candela (cd)  – the luminous intensity of a light source (the brightness of a light to the human eye)

Visit Module 16 Reception to see The Measure of All Things interactive demonstrations, featuring the SI units.

About your visit

This guide should provide you with all the information you need to enjoy your visit to NPL.

All information in this booklet was accurate at the time of printing. Any details that have changed since will be communicated to you on the day of the Open House.

As we are a working laboratory, please appreciate that we are not able to open up all of our facilities. For your own safety, do not enter any restricted areas.

The lifts are located behind the main Reception in Module 16 and also between Modules 12 and 13.

There are no guided tours and some of the laboratories are quite small so please be prepared to queue.

You are welcome to visit as many or as few of the open laboratories as you like. It is a considerable distance from one end of the building to the other so you will not manage to see everything. The descriptions on the following pages will help you decide which facilities to visit, depending on your interests.

All personal items are the owner's responsibility, we do not take responsibility for any lost or stolen items.

Find out more about NPL and the science we do

A programme of short lectures will take place in the auditorium on the first floor of Module 16. There will also be scheduled talks in the large meeting room on the ground floor of Module 15 (G15-CS5).

Refreshments

The staff restaurant in Module 15, first floor, will be open to purchase light meals, snacks and drinks from 2 pm until 7:30 pm. Please do not take any food or drink away from the restaurant. There will also be snacks and drinks on the first floor of Module 1. Please note that the Module 1 refreshment point will only accept cash.

Children

Children are more than welcome, but the majority of exhibits are not aimed at those under 8 years old. Under 16s must be accompanied by an adult at all times. We are unable to accommodate buggies/prams.

Disability access

There is limited disabled parking and every effort has been made to provide assistance for disabled visitors, although some areas have limited access. Dogs are not allowed on site, with the exception of all assistance dogs. Unfortunately we are unable to provide wheelchairs. The lifts are located behind the main Reception in Module 16 and also between Modules 12 and 13.

Please note that some laboratories are not safe for implanted or body worn medical devices (like pacemakers).

Look out for the exhibits which are particularly child-friendly.

If you have any questions, please feel free to ask any of our staff, who will be wearing blue NPL polo shirts or visit the information/help point found in our main Reception, Module 16 – marked on the map.

As well as NPL scientists in the laboratories there will be a number of staff wandering around the building in blue NPL polo shirts, if you have any questions, please stop and ask them.

Photography & Filming

You are permitted to use hand-held cameras within NPL for private and non-commercial purposes, but you must not use cameras in any areas where video or photography is restricted or you are asked not to do so.

Official NPL photographers will be taking photos throughout the day, please indicate to them if you do not wish to be photographed.

LGBT+

As part of NPL's continued commitment to diversity, equality and inclusivity we are proud to be supporting the International Day Against Homophobia, Biphobia and Transphobia (17 May). You can find out more at www.dayagainsthomophobia.org
How many rainbows can you see around NPL today?

Please see the centrefold map to help find your way around

Open Laboratories Guide

The following descriptions of the laboratories you can see today are organised in Module order. See the map at the centre of this booklet to see where each Module is.

Module numbering:

F = First Floor; G = Ground floor; 1 – 16 = Module numbers
(so G5 = Module 5 Ground Floor) – followed by specific location, e.g. L21 or CS1, exact location is marked on the map in the middle of the booklet.

Car Park A (Module 16 Reception)

NPL's Hydrogen car

Car Park A (M16 Reception)

NPL has a hydrogen-powered Toyota Mirai, one of the world's first hydrogen-powered production vehicles, that staff can use for business trips and outreach activities. To find out more about NPL's ongoing research on in situ measurement techniques to support the improvement and lifetime performance of hydrogen fuel cells, please visit Fuel cell technology for greener cars - Module 8 First floor (F8-L5). The NPL site is also home to London's first public-access electrolyser-powered hydrogen refuelling station. The hydrogen is generated here using only water and electricity and is capable of generating enough hydrogen to refuel 16 cars each day.

Focus area: Energy and Environment

NPL's DIAL van

Car Park A (M16 Reception)

NPL has a facility, mounted on the back of an articulated lorry, which uses DIAL (Differential Absorption Light detection and ranging) technology to collect data and carry out assessments of environmental emissions. It uses state-of-the-art infrared and ultraviolet light technology that provides rapid, accurate measurements of airborne atmospheric pollutants. The system is a completely self-contained mobile laboratory that carries a suite of additional measurement equipment to monitor meteorological parameters and ambient gas concentrations. The DIAL system is able to monitor atmospheric pollutants remotely, at ranges of up to 3 km. The measurements are real-time, directly traceable to primary standards of gas concentration and are free from interference and contamination. DIAL is particularly useful for measurements of emissions from tanks, flares and diffuse sources, like landfill sites.

Please note that access to the van is limited in terms of numbers and also due to stairs.

Focus area: Energy and Environment

Precision agriculture

Car Park A (M16 Reception)

NPL is involved in agri-tech research, looking for new opportunities for technology and products that will assist in the feeding of a projected 10 billion people global inhabitants by 2050. Accurate and repeatable measurement is key to developing the next generation of wheat (and other crop varieties), through correct trait analysis and cross-breeding. NPL's innovative use of current commercially available vision systems, such as time of flight and 3D cameras, is helping to deliver a field-deployable 3D imaging demonstrator capable of covering 2.5 hectares/hour with centimetre positioning accuracy.

Focus area: Energy and Environment

Module 1

Testing antennas for emerging wireless communications

Module 1 Ground floor (G1-L11)

Antennas are electrical devices that convert electricity into radio waves, and vice versa, and are used with radio transmitters and receivers to receive and emit signals. Electrically small antennas are used in everyday wireless devices, like smartphones. Come and see our antenna range where we test the performance of these antennas using a unique optical fibre solution within a room designed to absorb all reflections of electromagnetic waves and insulate sources of radio wave interference. By leading the world in testing and validating new wireless technologies we provide a competitive edge to industry.

Focus area: Digital

Testing microwave antennas for radar and mobile phones

Module 1 Ground floor (G1-L16)

Come and see our (very impressive looking) microwave anechoic chamber, and learn about how we use it to study and calibrate microwave antennas used in a range of technologies, including remote sensing, radar and mobile phones. Our microwave anechoic chamber has been specially designed to have almost no microwave echoes, so we can test the antenna performance with no outside influences. This means we can help consumers receive a reliable performance and assist UK business.

Focus area: Digital

Increasing security using biometric recognition

Module 1 First floor (F1-A6)

Biometric technologies measure a variety of anatomical, physiological and behavioural characteristics including fingerprints, faces, and even your eyes. Biometrics are used to distinguish between different people, to check their identities (you may have a biometric passport that you've used at an ePassport gate). Come and see how we develop and improve methods to tests biometric systems, for both government and industry.

Focus area: Digital

Making single-electron devices

Module 2 Ground floor (G2-L4)

Electronic devices, like computers and smartphones, work by controlling a flow of hundreds to billions of electrons. As devices become smaller and smaller the flow of electrons also shrinks until the device is controlled by individual electrons. NPL has been developing single-electron devices to create a new standard for the SI ampere. We conduct our research in extreme environments, at temperatures only one hundredth of a degree above absolute zero, in a magnetic field three hundred thousand times bigger than Earth's, and with devices one thousand times smaller than the thickness of human hair. Come and see how we make these tiny devices, how we cool them using our 'fridge', and how we can trap and detect single electrons.

Focus area: Digital

SI unit: ampere

Measuring the smallest particles of light; assuring the security of quantum communications

Module 2 First floor (F2-LS1)

Quantum communications exploits the discrete and peculiar quantum properties of photons, which are the tiniest and most elementary particles of light. This technology can provide very high security for the transmission of sensitive data. In the near term, it could be used to supply the secret keys and random numbers that are an essential resource for cryptography; eventually it could be used in a secure global communication network operating over long-distance fibre and satellite links.

To support commercialisation of this technology, NPL is collaborating with the National Cyber Security Centre and academia to establish a world-leading test and validation facility focused on measurements at the level of individual photons.

This exhibit will introduce some of the basic principles of quantum communications, describe the challenges of measuring the most elementary particles of light, and explain NPL's work to develop trusted measurements and standards to test this technology.

Focus area: Digital

Making the most of renewable energy

Module 2 First floor (F2-L1)

Renewable sources can be intermittent and mean that electricity flows in two directions, so the electricity grid is more complex. We are working to make every stage of power, from generation to use, more efficient, safer and affordable. A 'smart grid' can do this by measuring how the grid is changing second by second and respond quickly to changes in supply and demand. Our equipment measures how the grid's high voltages and current get distorted by modern electronic devices. Come along and see what effect everyday appliances have on the grid - some of them may surprise you.

Focus area: Energy and Environment

Magnetics

Module 2 First floor (F2-L6)

Magnetism and magnetic materials have been fascinating people since their discovery by the Greeks over 1,500 years ago and now permeates almost all aspects of modern day life from computers to power generation. At NPL the magnetics laboratory tests a variety of magnets for the automotive and aerospace industry as well as developing techniques that utilise magnetic fields. Come and experience the world's strongest 'fridge' magnet and see a number of interactive and fun displays that will demonstrate the wonder of magnetism.

Focus area: Advanced Manufacturing

Module 3

Supporting manufacturing: Coordinate Measuring Machines

Module 3 Ground floor (G3-L5)

Advanced manufacturing needs precise control of machinery and parts. Coordinate measuring machines (CMMs) are used for measuring the dimensions of complex components in a wide variety of industries, from aerospace to medical implants. CMMs will help pave the way to smart factories and increased automation. Come and see how NPL is optimising both contact and non-contact CMMs.

Focus area: Advance Manufacturing

SI unit: metre

Measuring temperature with sound

Module 3 First floor (F3-L1)

The temperature of an object is an indication of the average speed with which the atoms and molecules within that object are jiggling. But it is difficult to make the connection between the speed of molecular motion and the temperature in degrees Celsius. In this laboratory we make that connection. This is a rare chance to see the NPL-Cranfield Acoustic Thermometer, the most accurate thermometer in human history, which uses precise measurements of the speed of sound in a gas to infer the speed of molecular motion. Visit G5-L13 to learn about measuring temperature with light.

Focus area: Energy and Environment and Advanced Manufacturing

SI unit: kelvin

3D Imaging for agriculture

Module 3 First floor (F3-L2)

Capturing detailed data on field grown crops presents a huge measurement challenge, but is critical for a sustainable global food supply. In this laboratory we will demonstrate several imaging technologies utilised in crop breeding programmes and by automated harvesting vehicles. There will also be an opportunity to capture yourself in 3D and understand the capabilities and limitations of the current technology.

Focus area: Digital

Human hydration monitor

Module 3 First floor (F3-L2)

We are all familiar with the wearable technology market and how we can monitor heart rate & distances travelled with devices strapped to our bodies. However, there is currently no solution for accurately monitoring a person's hydration and this has a significant impact on cognitive ability, fatigue and performance. NPL has developed a method to monitor directly a person's blood supply non-invasively, providing hydration information for sports, healthcare, extreme environments and even veterinary applications.

Focus area: Life Sciences and Health

From metre realisation to practical measurement

Module 3 First floor (F3-L13)

The metre is one of the seven base units of the International System of units (SI). It has evolved from a concept based on the size of the Earth, through the use of metal standard bars of various shapes, through vapour lamp wavelengths, to its present day realisation based on the speed of light. Practical standards based on the metre have evolved too, resulting in the latest generations of laser interferometers which use interference of electromagnetic waves to make measurements. This exhibit gives a brief history of the metre, but concentrates on practical metrology performed today. Come and find out about laser trackers, which are found throughout aerospace manufacturing for accurate measurements.

Focus area: Advanced Manufacturing

SI unit: metre

Module 4

Investigating Graphene and 2D materials

Module 4 Ground floor (G4-L11)

Graphene is a newly discovered material (in 2010 two scientists at the University of Manchester received the Nobel Prize in Physics for its discovery). It consists of a single layer of carbon atoms in a honeycomb structure, and has a range of remarkable properties, being very strong, elastic, and a superb conductor of electricity and heat. Graphene has many potential uses, and at NPL we study its properties to understand how this unique material will behave under industrial conditions, and provide standards and regulations to increase the reliability and reproducibility. Come and learn more about this important material and see how we research its properties.

Focus area: Digital and Quantum

Comparing the most accurate clocks in the world

Module 4 Ground floor (G4-L15)

Our frequency combs are used to compare NPL clocks operating at different frequencies. We also use optical fibre links to compare our optical clocks with similar clocks developed independently in other laboratories around Europe. This enables us to check their accuracy in preparation for a future redefinition of the second and for new applications such as gravity sensing.

Focus area: Digital and Quantum

SI unit: second

Optical atomic clocks

Module 4 Ground floor (G4-L16)

The next-generation atomic clocks will be capable of measuring 1 second to 18 decimal places, which is even more accurate than the caesium clocks we currently use to realise the SI second. All clocks rely on an oscillator that 'ticks' at a constant rate, such as a quartz crystal. Optical clocks use laser light for the oscillator, with around 500 million million (500 000 000 000 000) ticks per second. Come and meet the scientists who will show you the experiment and tell you more about the applications of optical clocks for navigation, gravity sensing and testing fundamental physics.

Focus area: Digital and Quantum

SI unit: second

Defining the second with NPL's Caesium Fountain Clock

Module 4 Ground floor (G4-L20)

The NPL Caesium Fountain Clock is among a handful of the most accurate long-term timekeepers in the world, and is used to define the globally-standardised timescale. An atomic fountain uses lasers to cool balls of atoms close to absolute zero, and then to throw them upwards. As the atoms fall (like in a fountain), their internal oscillations are counted precisely to define the unit of time, the second. Come and learn about our Caesium Fountain Clock, and hear how it contributes to the worldwide International Atomic Time and Coordinated Universal Time (UTC) scales, vital for global communications, satellite navigation, financial transactions and more.

Focus area: Digital and Quantum

SI unit: second

Observing the Earth and climate change from space

Module 4 First floor (F4-L6)

The Earth is warming, driven substantively by mankind. But what temperatures will it reach and what will that mean? NPL is looking to improve the accuracy in the data so that these questions can be more accurately answered. Come and see how we measure incoming and reflected solar radiation using satellites in space, and how we monitor the health of our planet. Learn more about our current work on measuring the colour of the oceans, of sand and salt in deserts, and the reflectance of leaves in forests.

Focus area: Energy and Environment

SI unit: candela

Ground floor

First floor


Evacuation Assembly Area
Information/help
Stairs
Lifts
No entry to visitors
Unsuitable for implanted or body worn medical devices
First Aid Point
Toilets
Restaurant
Quantum science and Technology exhibits
Child-friendly exhibits
Refreshments point (Drinks and snacks available to purchase from 2 pm - 7:30 pm)
Biometric recognition (F1-A6)
Magnetics (F2-L6)
History of computing and mathematics at NPL (F12-CS6)
Measuring the smallest particles of light (F2-LS1)
Enhancing renewable energy (F2-L1)
3D Imaging for Agriculture (F3-L2)
Human Hydration Monitor (F3-L2)
Measuring temperature with sound (F3-L1)
Metre realisation to practical measurement (F3-L13)
Observing the Earth and Climate Change from Space (F4-L6)
Time for the UK (F4-L22)
Labs related to each SI base unit:
metre (m)
kilogram (kg)
second (s)
kelvin (K)
ampere (A)
mole (mol)
candela (cd)
Refreshments point (Drinks and snacks available to purchase from 2 pm - 7:30 pm)
Lecture theatre (F16-CS1)
Mass spectrometry imaging (F7-L3)
Gas reference standards (F7-LS1 & LS2)
Fuel cell technology for greener cars (F8-L5)
Using light to measure greenhouse gases (F8-L20)
Air pollution caused by nanoparticles (F8-L16)
3D printing in action (F9-L2)
Underwater acoustics (F10-L12)
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Time for the UK

Module 4 First floor (F4-L22)

In this laboratory we generate the national time scale, UTC(NPL), based on a group of continuously running atomic clocks that count time in nanoseconds - billionths of an SI second. Come and discover how we keep the time scale in step with Coordinated Universal Time (UTC), the global reference for timekeeping, and compare it with other national time scales throughout the world using satellite signals. Find out how our internet time service and MSF radio time signal disseminate time 24/7 across the whole of the UK, and the NPL*Time*® service enables the financial sector to meet new regulations by providing accurate and reliable time through optical fibre links.

Focus area: Digital and Quantum

SI unit: second

Module 5

Time and Frequency

Module 5 Ground floor (G5-LS1 & LS2)

NPL is the home of the national time scale UTC(NPL) and our scientists are developing ways to measure time with increasing accuracy. Come and find out more about the science and technology behind our atomic clocks and why we need these incredibly accurate methods of timekeeping for financial trading, navigation, energy networks and digital communications. You can also test your skills on our interactive model of an ion trap.

Focus area: Digital and Quantum

SI unit: second

Measuring temperature with light

Module 5 Ground floor (G5-L13)

Most measurements of temperature are made by placing a thermometer in contact with an object, but often this is inconvenient or impossible. In this laboratory we will demonstrate two techniques which allow measurements of the temperature of an object without needing to touch its surface. In the first technique, the infrared light emitted by objects is detected to create thermal images from which the temperature can be deduced. In the second technique, an object is coated with a paint which fluoresces after it has been illuminated – similar to 'glow-in-the-dark' paint found on clock faces. By measuring the speed which the fluorescent light fades, the temperature can be deduced. Visit F3-L1 to learn about measuring temperature with sound.

Focus area: Advanced Manufacturing

SI unit: kelvin

Building 55

Treating cancer with Clinical Linear Accelerators

Building 55

A linear accelerator (LINAC) is the most commonly used equipment for external beam radiation treatments for patients with cancer. LINACs are particle accelerators, similar in principle to the particle accelerators used at CERN, and they destroy cancerous cells by bombarding them with precise, high-energy X-rays, sparing the surrounding healthy tissue. At NPL we use our LINAC to calibrate the accuracy of hospital radiotherapy facilities, and conduct research to further improve LINAC treatments. Come and visit the LINAC facility to learn more about how the accelerator works, and hear how our research is enabling the delivery of world-class cancer care by the NHS.

Focus area: Life Sciences and Health

Module 6

Nuclear medicine

Module 6 Ground floor (G6-L3)

Close to 1 million people in the UK undergo a nuclear medicine procedure each year. This involves the injection of a radioactive isotope, often attached to a specific drug, in order to diagnose or treat diseases like cancer. To ensure diagnosis is accurate and therapies are successful, NPL works closely with the UK nuclear medicine community to provide calibration standards, good practice guides and ground-breaking research, leading to improved quality of life for patients. Come and learn about radioactivity and see our new unique SPECT-CT-PET scanner and 3D printed anatomical models, with interactive demonstrations throughout the day.

Focus area: Life Sciences and Health

Mass spectrometry

Module 6 Ground floor (G6-L6)

The mass spectrometry laboratory is used for the measurement of long-lived, low level radioactivity, primarily aimed at clean-up of closed reactor sites, routine monitoring of the surrounding environment, and determining the source of contamination. This lab demonstrates the principle of how low-level radioactivity can be measured by its mass, and how this capability has expanded the measurement options for end users, whilst offering more rapid assessment of radioactivity compared to traditional measurement techniques.

Focus area: Energy and Environment

Through the looking glass: applying optics in the real world

Module 7 Ground floor (G7-L1 & L2)

Optical technologies use light, visible radiation that the human eye can detect, and at NPL we study the optical performance of a wide variety of instruments and materials. See colour holograms, observe Brownian motion, as explained by Albert Einstein, with a microscope and discover the applications for microlenses, including 3D photography. See how light can be guided through a transparent medium and discover the principles of total internal reflection and refractive index.

Focus area: Advanced Manufacturing

Accurate measurements of high forces

Module 7 Ground floor (G7-L9, L23 & L24)

Measuring force is important in lots of industrial applications, from determining the thrust produced by aeroplane engines, to calculating the weight of very large structures. NPL is home to a set of seven high-accuracy force standard machines that generate a wide range of accurately-known forces in both tension and compression. Come and see these machines and find out how they are used to guarantee reliable force measurements in industry.

Focus area: Advanced Manufacturing

National standard kilogram and the Kibble balance

Module 7 Ground floor (G7-L18)

The kilogram is currently defined by a physical object – the International Prototype Kilogram (IPK) kept at the international standards laboratory in Paris. NPL has the role of looking after the UK's copy of the IPK. Come and see how it is stored and cleaned, and how it is used to underpin all weighing performed in the UK. From next year the kilogram will be defined in terms of a fundamental constant using a Kibble balance. You can find out how NPL devised this experiment and see a demonstration of how it will be used to replace the IPK. You will also be able to weigh yourself and have it traceable back to the UK's national standard; and see if you can 'beat' the dolls of confusion.

Focus area: Advanced Manufacturing

SI unit: kilogram

Gas reference standards: making and measuring

Module 7 First floor (F7-LS1 & LS2)

The measurement of different types of gases is critical to our quality of life. Everything from the cost of our gas bill to the safety of the air we breathe relies upon the accurate measurement of gas mixture compositions. Indoor air pollutant concentrations can be up to five times that of outdoor air. Therefore emissions from household products is a new area of great importance. Our team is among the best in the world at preparing and measuring gas mixtures. Come and see how we do this by preparing your own 'bean' reference standard in a balloon to take home, then use your nose as a detector to identify how fragrances and flavours are influenced by traces of volatile organic compounds.

Focus area: Energy and Environment

Mass spectrometry imaging

Module 7 First floor (F7-L3)

Improving our understanding of disease requires new knowledge of the biological processes involved. In mass spectrometry imaging, ions generated from the surface of a sample are measured so that the identity of the original molecules and their location to be determined. This information is used to create a detailed molecular map of the sample, which can be analysed to uncover hidden relationships between the molecules, and give insights into the disease itself. Here at the National Centre of Excellence in Mass Spectrometry Imaging (NiCE-MSI) we are applying this exciting and powerful technology to investigate disease at a molecular level, helping identify new targets for next generation therapies.

Focus area: Life Sciences and Health

Module 8

Understanding materials at the atomic level

Module 8 Ground floor (G8-L3)

The development of the next generation of medical and electronic devices will rely on knowledge of materials, particularly their surfaces and interfaces. In this laboratory there is a unique suite of instruments and the knowledge to realise the full potential of spectroscopy and imaging at the atomic and molecular scale, known as 'nanoanalysis'. This provides UK industries with access to advanced measurement capabilities. Our world-leading research helps to design cutting-edge materials and products. Come and see nanoscale images of individual cells, showing the chemical differences in the cellular structure and how we can use this to help develop targeted drug delivery, as well as find out what we can tell about your diet from the change in your pocket.

Focus area: Advanced Manufacturing

Fuel cell technology for greener cars

Module 8 First floor (F8-L5)

Fuel cells are rapidly emerging as an alternative energy source. The energy stored in the fuel is directly converted to electricity, rather than simply burning the fuel. Fuel cells in cars run on hydrogen gas, with water the only waste product, helping reduce CO_2 emissions and improve air quality. NPL is developing measurement techniques and tests to help the UK industry to manufacture more durable and cost effective fuel cells. And we are supporting the rollout of a hydrogen refuelling network for cars by hosting a public refuelling station on the NPL site. Visit us to find out more about this environmentally-friendly technology, see our model fuel cell car, and learn about our hydrogen refuelling station.

Focus area: Energy and Environment

Air pollution caused by nanoparticles

Module 8 First floor (F8-L16)

Gases like carbon monoxide are one indicator of pollution, but tiny particles, such as the soot produced by car engines, are another type of pollution that can have a great impact on our health. These nanoparticles are more difficult to measure and sample than most gases, but NPL can measure their concentration and the size. We'll demonstrate some of our key techniques using everyday equipment such as a kettle and a drum, and find out how pollution in the laboratory compares with the outside world.

Focus area: Energy and Environment

SI unit: ampere

Seeing the invisible: using light to measure greenhouse gases and pollutants

Module 8 First floor (F8-L20)

We can use a range of light technologies to measure atmospheric pollution and greenhouse gases in a huge variety of scenarios. NPL measures emissions from chimney stacks, carries out laser radar mapping of methane emissions from rubbish dumps, puts lasers on balloons that can measure greenhouse gases up to 30 km altitude, and uses thermal imaging to find leaks of greenhouse gases from industry. NPL is improving the quality of data available to government, industry and the public related to the monitoring of air quality and emissions, identifying pollution sources, and helping the UK to meet stringent international regulations. Come and see the carbon dioxide in your breath and enjoy other demonstrations.

Focus area: Energy and Environment

SI unit: mole

Module 9

Monitoring the health of large structures using robotics

Module 9 Ground floor (G9-LS1 & LS2)

Bridges, tunnels or nuclear plants can all be monitored with sensors to ensure that they are structurally healthy. It is important to check for erosion, corrosion, damage or just wear and tear. At NPL we are experienced in using Digital Image Correlation (DIC) to look at the changes caused by cracking in concrete structures, deflections in bridges and the changes over time of really large structures. We are making the UK's nuclear industry safer through cost-effective decommissioning and automation of hazardous activity. We will be demonstrating how this technique can make management of large scale UK infrastructure safer and more efficient.

Focus area: Advanced Manufacturing

Explore the world in miniature with electron and ion beam microscopes

Module 9 Ground floor (G9-L1)

To know how to make materials better – for example stronger or safer – we need to be able to see their structure at magnifications of up to 1 million times or more. Ordinary light microscopes can't do this, so we use electron microscopes that allow us to see features 10,000 times smaller than the width of a human hair. Such small scales can be hard to comprehend, so come and see the structure of a human hair revealed by an electron microscope. Then see an ion beam microscope which can cut into the surface of materials to find out what's underneath and see how the world's smallest Christmas card was made here.

Focus area: Advanced Manufacturing

3D optical microscopy

Module 9 Ground floor (G9-L10)

Three-dimensional optical microscopy is a new technique in which we can investigate objects on tiny scales, but in three dimensions. 3D microscopes provide fascinating insights into surfaces of materials, which can be used to modify them and make them more resistant to damage. Come and watch a 3D optical microscope in use, and see how it can be used to investigate the surfaces of a wide range of materials.

Focus area: Advanced Manufacturing

3D printing in action

Module 9 First Floor (F9-L2)

3D printers make solid objects by building up layers of material to form 3D shapes. They're used widely in industry to produce highly complex and customised parts quickly; from jet engine parts to medical implants. We are helping businesses to become more productive, responsive, sustainable, and efficient by using new manufacturing techniques. At NPL we're working on ways to measure accurately and validate 3D printed parts, to help guarantee their quality and to make sure a greater variety of objects can be 3D printed. The machine you'll see today is a 'hobby level' printer, a type which we've used to develop mechanical parts, and even to create new materials with novel electromagnetic properties.

Focus area: Advanced Manufacturing

Medical ultrasound

Module 10 Ground floor (G10-L1)

Ultrasound is sound waves with frequencies higher than the upper audible limit of human hearing. Devices using ultrasound can detect objects and measure distances, so can be used in medicine, for non-destructive testing of products and structures, cleaning and to accelerate chemical processes. At NPL, ultrasound activity supports diagnostic science for precision medicine by developing and supporting advanced ultrasound imaging technologies, specifically those providing quantitative images. Our world-leading therapeutic ultrasound research helps to develop and define new standards to measure critical dose-relevant parameters for emerging treatment. Come and visit us and get sprayed by the acoustic fountain, see the sonic lightning ball, and hunt for diseased tissue with an ultrasound scanner.

Focus area: Life Sciences and Health

Underwater acoustics

Module 10 First floor (F10-L12)

Underwater acoustic work addresses key challenges related to marine defence, security and energy supply resilience, sustainability and environmental protection. Underwater acoustics research enables the protection and sustainable exploitation of the marine environment through provision and dissemination of traceable standards, which will enhance UK competitiveness in the marine technology industry, and underpin key strategic defence and offshore energy applications. Come and see our exciting demonstration in the large acoustic test tank (five metres deep), where we test and calibrate hydrophones and sonars used for underwater acoustics. You can also hear about man-made underwater noise and how it affects marine mammals and fish.

You will also have the opportunity to make some underwater noise driving radio-controlled model boats around the test tank, learning how and why ship noise is monitored in our oceans.

Focus area: Energy and Environment

Module 12

Engineering Services workshop

Module 12 Ground floor (G12)

Much of the equipment used by our scientists is designed and made at NPL in the engineering workshops. The Design Office is staffed by a team of qualified engineers and equipped with an Interactive Computer Aided Design System. NPL Engineering provides a mechanical engineering service covering a wide range of machining, assembly and commissioning work. Come and see examples of the work carried out, and how different items are designed and made.

Focus area: Advanced Manufacturing

History of computing and mathematics at NPL

Module 12 First floor (F12-CS6)

NPL played a major part in the development of modern computing, including Alan Turing's Pilot ACE, and the world's first packet-switching network (the technology on which modern networks are based). A selection of photographs and artefacts will show you the leading role that NPL played in the 1960s in the marriage of computers and communications. Also, see how simulation techniques based on random events provide essential underpinning to aspects of NPL's work.

Module 14

Liquid Nitrogen Show

Module 14 Ground floor Teaching Lab (G14-CS1)

Liquid Nitrogen Show - Andrew Hanson and the NPL Liquid Nitrogen Team.

On the hour and half-hour starting at 2.30 pm and ending at 7.00 pm.

Capacity is 40 people, please expect to queue and access is on a first-come, first-served basis.

Module 15

NPL video and photo archive

Module 15 Ground floor (G15-CS4)

Come and see some of our historical footage of NPL from the last 70 years or find out about some of the open laboratories with our introductory videos. The films will loop continuously throughout the event.

The Glazebrook Association

Module 15 Ground floor (G15-CS4A)

The Glazebrook Association, named after Sir Richard Glazebrook the first Director of NPL, is a social group for former employees of NPL. In addition to enabling former colleagues and their families to keep in touch with one another and with NPL, through meetings, activities and newsletters, the Association is keen to help the NPL remember and record its wonderful history of scientific achievements. Come and meet us for a chat, indulge in enjoyable recollection of the past, and spot yourself or your parents in photograph records of the laboratory.

Module 16

Cancer Research UK

Module 16 Reception

CANCER RESEARCH UK GRAND CHALLENGE

Cancer Research UK's vision is to bring forward the day when all cancers are cured. In the 1970s, less than a quarter of people with cancer survived. But over the last 40 years, survival has doubled – today half will survive. The ambition is to accelerate progress and see three out of four people surviving the disease within the next 20 years.

NPL is leading a team, chosen by Cancer Research UK in their £100M inaugural Grand Challenge competition, and using our expertise to create a 'Google Earth' view of tumours and helping to beat cancer sooner. In the same way cartographers build maps of cities, countries and the world to help people get around, scientists build maps of tumours to better understand their inner workings in the hope it will lead to new ways to diagnose and treat cancer. The NPL team of chemists, physicists and biologists are using their expertise to develop a reproducible, standardised way to fully map different tumours in unprecedented detail.

All money raised from the Open House will go to Cancer Research UK.

Work, study and train at NPL

Measurement skills are vital to the competitiveness of UK industry, helping businesses improve quality, productivity and trade, but they are not available through conventional education. Drawing on our century of measurement expertise, NPL provides world-class training and learning, from early interest to expert level, to enable UK industry to benefit from these vital skills now and in the future.

The Postgraduate Institute for Measurement Science

Module 14 Ground floor (G14-CS6)

NPL has close links and collaborations with many universities around the UK. The postgraduate researchers will be able to tell you about the research they are doing and the Postgraduate Institute events that have taken place or are being planned for the future.

NPL Training

Module 14
Ground floor
(G14-CS6)

NPL Training is used widely in industry to help businesses make the most of their measurement systems. Come and try some fun activities that demonstrate why measurement is so important, make a pendulum and see how quickly it diverges from Coordinated Universal Time, try your hand at darts to test your accuracy and precision (two different measurements.

Cultivating the measurement skills needed to increase UK productivity, from entry to expert level.

Interested in a future career in science, engineering or business?

Module 14 Ground floor (G14-CS6)

NPL and its Resourcing team are passionate about inspiring the next generation. Please come and find out more about 'Labtastic', our holiday Science Camp that we run for 13 and 14 year olds; The NPL Academy, which is a work experience programme for 15–18 year olds; and our exciting Apprenticeship programmes that offer career opportunities for school leaves who are interested in Science, Engineering and Business. Our friendly team can answer any questions you might have, and you can meet some of our current Apprentices to ask them what life is really like as an Apprentice at NPL.

History of NPL

For over a hundred years NPL's scientists have made world-changing discoveries and inventions, such as the development of radar, Alan Turing's creation of the UK's first programmable computer, and packet switching, a data communication method that shaped the development of the internet.

Our scientists continue this proud tradition of innovation today, creating cutting-edge science and technology in fields as diverse as quantum computing, biosciences, materials science and climate observation.

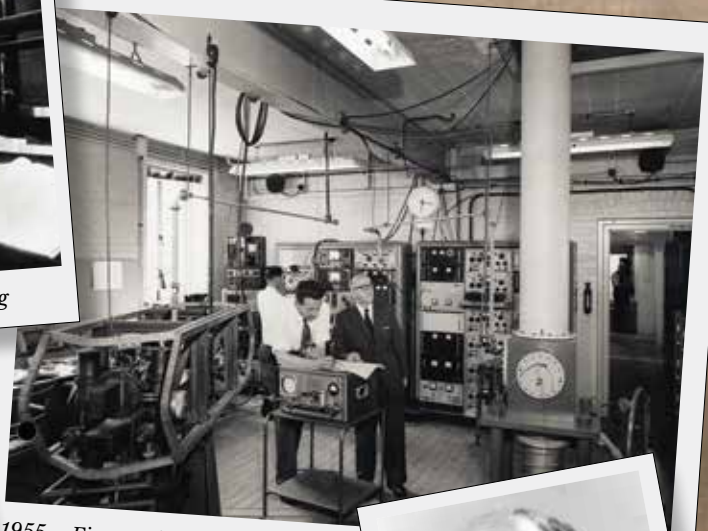
The National Physical Laboratory was formally opened on 19 March 1902 by the Prince of Wales

1910 – Building of the first ship tank was completed

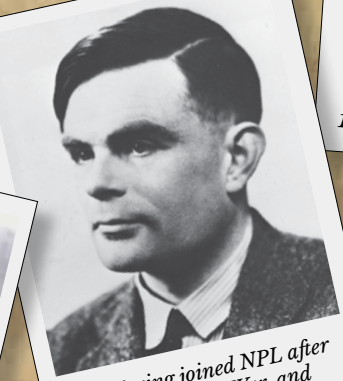
NPL began testing taximeters in 1907 (taximeters being tested in the 1940s pictured)

1950 – A pilot model of the Automatic Computing Engine (Pilot ACE) designed and built at NPL

Late 1920s – Thermometer testing



1955 – First caesium atomic clock



Alan Turing joined NPL after the Second World War, and from 1945 helped design the Automatic Computing Engine (Pilot ACE)

Mobile acoustical laboratory launched in 1947

In 1966 Donald Davies developed packet switching, a data communication technique upon which the internet is founded

See some of our historical footage in Module 15, ground floor.
Find out more about the early days of NPL by visiting
www.npl.co.uk/about/history

Events you might be interested in:

NPL

WATER ROCKET CHALLENGE

WATER + ROCKETS =
GREAT DAY OUT

Wednesday 20 June 2018

WWW.NPL.CO.UK/WRC

If you notice an unattended package or a lost child, please inform one of the NPL members of staff.

Safety signs

Around NPL visitors will encounter a great many safety signs; for your own safety it is important that you understand their meaning and significance.

Prohibitive Red on a white background	**Mandatory** White on a blue background	**Safe condition** White on a green background	**Hazard warning** Black on a yellow background	**Information** Black on a white background
				
Example depicted: *'No unauthorised persons'*	Example depicted: *'Eye protection must be worn'*	Example depicted: *'First Aid point'*	Example depicted: *'Laser hazard'*	Example depicted: *'Litter bin provided'*

Fire

If you discover a fire, sound the alarm by breaking the nearest call point and inform a member of NPL staff immediately. There is a voice evacuation message. Leave the building immediately and report to the assembly point indicated on the map.

Do not attempt to fight the fire.

Evacuation

Should the need arise to evacuate a building or module during your visit, a continuous voice message will be heard. If there is a standby voice evacuation message please await further instructions from NPL staff.

The following actions must then be taken:

- Report immediately to the assembly area at the back of the main building at the south end of site, by Bushy Park
- Don't linger to collect personal belongings
- Don't use lifts
- Please clear the area for the emergency services
- Obey any instructions given by NPL staff, fire officers or members of the incident response team

First aid 

For any medical emergency, assistance can be summoned by dialling 3333 on any internal telephone. Medical welfare facilites are available to all visitors if required.

Smoking 

NPL is a non-smoking site, smoking is not permitted in any building or the service roads between the Modules.

Pacemakers 

Please note some of our laboratories are not safe for implanted or body worn medical devices (like pacemakers).

CCTV

Please note that certain areas of the site are covered by CCTV cameras.

Today's talks

Module 16, First floor, Lecture theatre

Capacity is 130 people, please expect to queue and access is on a first-come, first-served basis.

Time	Speaker	Subject
2.30 pm	Martyn Sené	Introduction to NPL
3.00 pm	Fiona Auty	The Measure of All Things
3.30 pm	Rebecca Nutbrown	NPL support for radiotherapy in the UK
4.00 pm	Gareth Hinds	Batteries for electric vehicles
4.30 pm	Ian Robinson	The Kibble balance and redefining the kilogram
5.00 pm	Martyn Sené	Introduction to NPL
5.30 pm	Fiona Auty	The Measure of All Things
6.00 pm	Anne Curtis	Harnessing time
6.30 pm	Gareth Hinds	Batteries for electric vehicles
7.00 pm	Ian Robinson	The Kibble balance and redefining the kilogram

Module 14, Ground floor, Teaching Lab (G14-CS6)

Capacity is 40 people, please expect to queue and access is on a first-come, first-served basis.

Liquid Nitrogen Show – Andrew Hanson and the NPL Liquid Nitrogen Team.
On the hour and half-hour starting at 2.30 pm and ending at 7.00 pm.

Module 15, Ground floor (G15 CS5)

Capacity is 50 people, please expect to queue and access is on a first-come, first-served basis.

Time	Speaker	Subject
2.30 pm	Stephen Giblin	Redefinition of the ampere 
3.00 pm	Perdi Williams	Working as an Apprentice and the Kibble balance
3.30 pm	Leon Lobo	Atomic timekeeping for the finance sector
4.00 pm	Fawzi Abou-Chahine	Going the distance
4.30 pm	Bajram Zeqiri	Ultrasound and baby's first photo
5.00 pm	Stephen Giblin	Redefinition of the ampere 
5.30 pm	Perdi Williams	Working as an Apprentice and the Kibble balance
6.00 pm	Leon Lobo	Atomic timekeeping for the finance sector
6.30 pm	Fawzi Abou-Chahine	Going the distance
7.00 pm	Bajram Zeqiri	Ultrasound and baby's first photo

Find out more about us

npl.co.uk

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#NPLOpenHouse

The Department for Business, Energy and Industrial Strategy (BEIS) owns NPL Management Limited (NPLML) and NPL operates as a public corporation in a strategic partnership with the University of Strathclyde and the University of Surrey; to develop joint research centres and to support the development of the Postgraduate Institute.