

CAREER VIEW

PHYSICS

How did the universe begin? What is everything made of? Is time an illusion? These are just three of the big questions that intrigue physicists as they explore the fundamentals of matter and energy, make discoveries and inventions and formulate new theories. Physics underpins our modern, technological society. Computers, mobile phones, household appliances, aircraft, robots, medical imaging all result from the work of physicists. Twentieth century physics put the first humans on the moon. In the 21st century completion of the Large Hadron Collider – the world's largest and highest-energy particle accelerator – enabled particle physicists to study the basic conditions of matter as it might have been in the universe one billionth of a second after the Big Bang. Then there is nanotechnology with its many applications. How about a teabag that cleans contaminated water or a laser the size of a virus particle? From the infinitely large to the infinitesimally small and all things in between, the work of physicists challenges every frontier.

WHY STUDY PHYSICS?

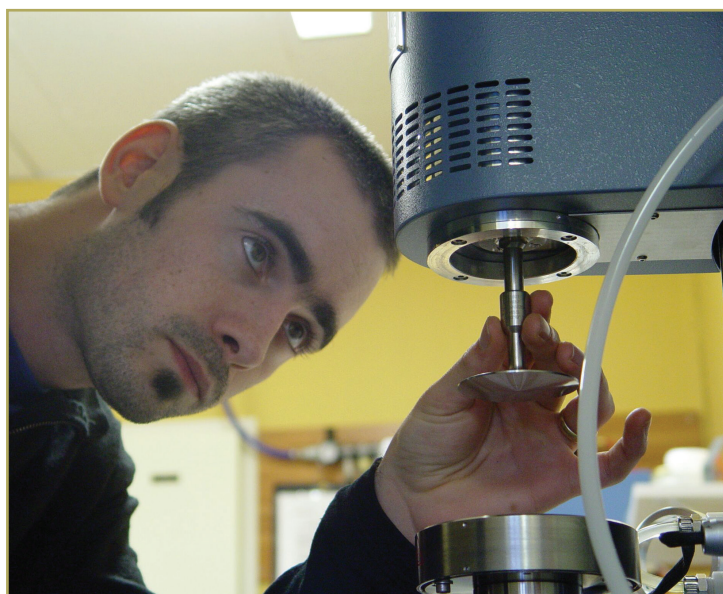
Physics is the most fundamental of all the sciences. It aims to understand how nature is put together and how it works. Physics examines matter and energy in all their forms, from the kinetic energy of a speeding car to the nuclear energy released by fusion in the core of a star. So the study of physics can lead into many different fields – food technology, textile research, electronics, instrumentation, computer hardware and software development, scientific measurement, renewable energies, meteorology, astronomy,

nanotechnology, geophysics, and the development and testing of new materials such as superconductors.

Physics graduates have highly transferable skills and are employed in a wide range of occupations. Pure research jobs with good career structures generally require very good qualifications. Some physics graduates move into related fields such as environmental science, geophysics, meteorology or computing. Ongoing technological changes will lead to future jobs that no one has even thought of.

WHAT SKILLS DO PHYSICS STUDENTS DEVELOP?

Mathematical skills. Mathematics is extremely important in physics and many students do a double major in the two subjects. It is impossible to do advanced theoretical physics without being completely at ease with advanced mathematical concepts. Mathematical modelling using computers is an important part of physics course work and is good preparation for work in non-physics areas.



Career View explores how degrees and courses relate to employment opportunities and to life/work planning. It includes graduate destination information and current employment issues. Your comments and suggestions are always welcomed.

Wellington Careers and Employment.
wgtn.ac.nz/careers



Not all areas of physics require such a high level of mathematics; many aspects of applied physics need only a good grounding in mathematics plus specialised study.

Analysis and problem solving. Why, what, how and when? Physics is the art of the problem solver – asking the hard questions and working through to a solution logically and analytically using evidence and ideas. Problems in physics can be complex and their resolution requires a careful, disciplined approach. Generally, physicists think about problems in analytical and quantitative terms, working on them theoretically before putting theory into practice. Students in physics gain high levels of abstract reasoning, accuracy and patience. These skills transfer very readily to other job areas, particularly management roles where strategic planning and decision making are significant components of the job.

Using scientific methodologies. Scientists have to be systematic and objective in designing, researching, setting up and implementing experiments and projects. Degree studies teach skills in scientific process along with a work ethic that demands rigour, safe and responsible practices and tolerance for repetition and patience.

Innovation and imagination. As in all sciences the instinct to "build things" and to create is important in electronic development work and many other aspects of physics. The ability to imagine "what if?" and envisage something that seems almost impossible is the driving force behind many modern technologies.

Technological skills are required in all advanced areas of physics, together with familiarity with appropriate software. Knowledge of computer systems is an advantage to many physicists particularly in electronic work, so inclusion of computer science courses in a Physics degree is worth considering.

Practical skills. Some employers in applied fields look for practical attitudes and know-how as much as for scientific expertise. In geophysical fieldwork for instance, common sense and the ability to fix instruments that are not working or make equipment out of what's available may be very important.

Communication and teamwork and other so-called soft skills are important in science. Many scientists work in groups, sometimes with clients and with people from other disciplines. Teamwork is essential, as is the ability to get on with other people and be good communicators. At university, students work on projects together and present their work to peers and staff. They also learn to write clearly and accurately.

WHERE DO PHYSICS GRADUATES WORK?

New Zealand needs versatile and innovative science graduates who can apply their knowledge and ideas to a variety of sectors including industry, education, health, environment and business. Most researchers go into applied science areas taking up positions in public sector research organisations including Crown Research Institutes (CRIs).

Callaghan Innovation. New Zealand's advanced technology institute is a mix of researchers, engineers, scientists, technologists, designers, entrepreneurs, advisors and administrators delivering self-help and on-demand services and tailored programmes for businesses to access research and development. It has research groups in advanced manufacturing, biotechnologies, Data & the Internet of Things (IoT), measurement (of time, length, weight/mass, volume) and advanced materials (metal, ceramic, plastic or concrete).

GNS Science provides Earth, geoscience and isotope research and consultancy services. It employs physics graduates, depending on qualifications and experience, to technician and physicist roles in the National Isotope Centre. A PhD is required for physicist roles. GNS Science develops measuring

equipment and the instrumentation used to assist industry in quality and process control and employs geophysicists with strong computer and mathematical skills. Heritage Materials is another specialist field that verifies antiquities, archaeological artefacts and taonga.

NIWA (National Institute of Water and Atmospheric Research Ltd) employs physics graduates in meteorology, biological modelling and physical oceanography.

The MacDiarmid Institute for Advanced Materials and Nanotechnology offers graduates research opportunities, sometimes with scholarship assistance. Major research themes include nano-engineered materials and devices; novel electrical, electra-optic and superconducting materials and conducting polymers. The Institute funds a range of Postdoctoral Fellowships for specific projects.

Robinson Research Institute is a multidisciplinary research institute that melds innovative engineering and applied physics to build advanced technologies for businesses worldwide, such as transformers and magnetic sensors. They have research assistant and postdoctoral roles.

Building Research Association of New Zealand (BRANZ) researches energy efficiency in buildings, indoor air quality in buildings (heat and moisture control and ventilation) and weather tightness. Their work is a mixture of research, commercial testing and work on standards and building codes.

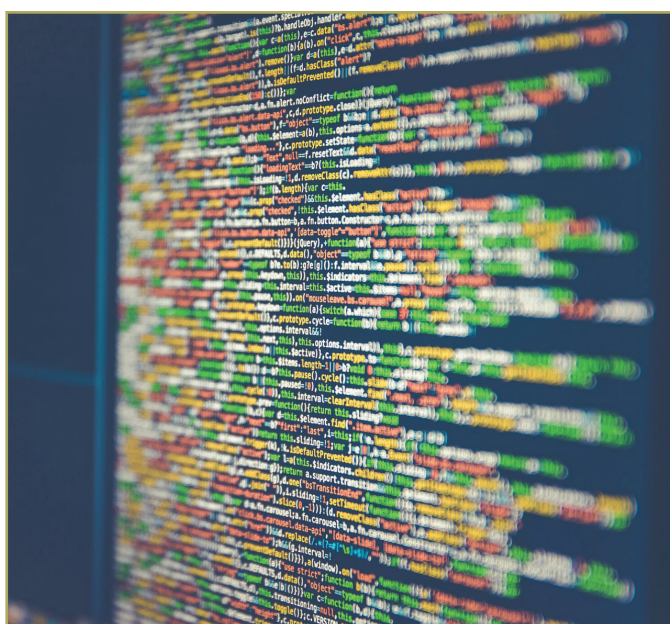
Industry and Commerce. Large industrial and manufacturing enterprises employ Physics graduates both in technical areas and in management.

Information technology and software. Because of their extensive experience in modelling systems, physics graduates often make good software developers because they have built up a solid background of working on very sophisticated and complex but highly quantitative problems. They can transfer those modelling skills into many other areas that use computer technology such as finance, economics, fisheries management and operations research. Many are employed by large ICT organisations and others find jobs in the growing number of small or start-up software development companies that are meeting clients' needs for specific applications. For example computer animation physics or game physics involves the introduction of the laws of physics into a simulation or game engine particularly in graphic interfaces so as to make the effects appear more real to the observer.

Electronics. Students can combine their interests in electronics with studies in computer science and/or physics. Graduates then go into a wide range of career options from research and development in CRLs, to industrial development or product development in the manufacturing industry. The New Zealand manufacturing industry ranges from large, well-known companies such as Fisher & Paykel or Tait Electronics, to specialised companies in the Wellington region such as Magritek or 4RF.

Nanotechnology is an exciting and growing area of employment and research for physicists both in New Zealand and overseas. Those wanting to work in this area ideally have a practical approach to problem solving (often using mathematical techniques), are able to reason clearly and communicate complex ideas, and are able to work in a company structure and under budgetary constraints. **Izon Science**, for example, designs and manufactures precision instrumentation for nano and micro-scale particle analysis around the world. Postgraduate physicists are useful in helping to model the ways the particles interact with a nanopore (a microscopically small pore in an electrically insulating membrane).

With the increasing demand for **energy** sources to be renewable and sustainable, there is a number of smaller companies, alongside the main energy providers researching and taking to market new technologies. In the field of renewable energy some small companies develop and manufacture or distribute products such as PV (photovoltaic) solar panels, grid connected inverters, wind turbines and other off-grid alternatives. **Sustainable Electricity Association of New Zealand (SEANZ)** represents the solar, small wind and mini hydro industry in New





MetService takes on trainee meteorologists according to demand to work as meteorologists. To be considered for meteorologist training, you must have a BSc, BSc with Honours or Master of Science in Mathematics or Physics (or Geophysics, provided your Maths/Physics background is strong). Physics graduates can also go on to do a PhD in Meteorology; their qualifications may lead into employment

Zealand and is a good way to find out about advances in this area. **Transpower NZ** transports electricity and manages the country's power system. The company has undergraduate and graduate programmes and employs people with strong analytical skills to roles that involve business analysis, financial and demand modeling and economic forecasting. Physics graduates have the required analytical skills and Economics is a very useful conjoint major or degree.

Medical physicists are employed in small but growing numbers in **hospitals and medical research** throughout New Zealand, working in aspects of radiotherapy and acoustic imaging (ultra-sound scanning). Graduates with a Bachelor of Science (BSc) in Physics can go on to specialised postgraduate training in medical physics at other universities in New Zealand and overseas. Occasionally PhDs in physics can go straight into medical physics but this is unusual.

New Zealand Defence Force (NZDF). The **Air Force** gives training in physics to trainee pilots, navigators and air electronics operators, so a degree in Physics can assist entry into these fields. It is also a basic subject in avionics and aircraft technician training. A BSc in Physics is regarded as a plus for competitive entry into officer training in the **Navy**. Education officers are employed in the defence forces to teach, for example, the theory of aeronautical dynamics and meteorology. The **Defence Technology Agency (DTA)** is a business unit of the NZDF. It provides applied research, exploratory development and policy studies on science and technology with application to military technology, force developments and operations.

at TV/Radio stations, research institutions and universities.

Geophysics. For solid earth geophysicists most opportunities lie in applied geophysics, particularly in oil, gas and mineral exploration. **GNS Science** employs geophysicists as scientific researchers and technicians, particularly in the area of earthquake seismology and tectonics. Opportunities are also available for physicists and geophysicists with private consultancy firms such as **Opus International's Laboratories** and **Groundsearch E.E.S. Ltd** in Auckland, especially for geophysicists with a strong practical bent and project management skills.

In industry as well as large scientific organisations there is a need for employees who are qualified in both **management** and a scientific or technical area. If you are keen on physics but are also interested in a business career, a conjoint Bachelor of Science and Bachelor of Commerce degree programme is an option, as is a postgraduate commerce qualification. Senior scientists in CRIs and in industry often become managers so inclusion of management courses within the BSc of research-oriented students can be helpful. Subjects to consider are: Management, Marketing, Accounting or Information Systems. Statistical and data analysis abilities are also very useful in business. Management consultants such as **Palantir** or **Boston Consulting Group** are examples of potential employers.

Operations research and data analysis. Physics graduates have a sound base in mathematical modelling that enables them to move into operations research – the application of mathematical and scientific concepts and techniques to the solution of

GRADUATE PROFILES

problems in government and industry. Government departments, consultancy firms and large companies have positions for operations researchers or business analysts. Courses in operations research and statistics can be included in a BSc. Postgraduate study in operations research and statistics is recommended for those wishing to pursue a long-term career in this area.

The **Intellectual Property Office of New Zealand (IPONZ)** grants patents and registers trademarks and designs. It employs patent advisors including those with physics degrees. Requirements for specific subjects however depend on the mix of specialisations within the office at the time. A science and law combination is ideal, but not necessary. Many patent advisors move on to work for **Patent Attorneys** with firms that specialise in intellectual property law. Further on-the-job study is required to become a qualified patent attorney.

Education. There are employment opportunities for educators and trainers in schools, colleges, polytechnics, universities and private training organisations. Physics is a key discipline within the education system. For secondary education teachers need a Bachelor or Honours degree together with a teaching qualification. Permanent positions at university or polytechnics require a PhD and research experience. Some organisations employ people with a scientific background as education officers.

JOB TITLES

The following is a sample of job titles taken from our graduate destination surveys. Some roles may require postgraduate qualifications and training.

Business analyst • clinical physicist (medical physics)
 • company founder • computer scientist • consultant
 • data analyst • electronics assembler/tester • game designer • geophysicist • instrument sales technician
 • laboratory technician • lecturer • management consultant • medical physicist • medical technician
 • medical scientific officer, radiation therapy • meteorologist • meteorological instrument technician
 • operations researcher • patent examiner • policy analyst • product designer • programmer analyst
 • research physicist • secondary teacher • systems analyst • seismologist • software developer • software engineer • textile researcher • trademarks adviser.

Tim Bunckenburg

Analyst
Ministry of Social Development



I was always pretty good at solving problems at school and I really wanted to do something that offered a challenge. It's not in my personality to cruise through and have everything come easy. I did a BSc majoring in Physics as well as doing Philosophy courses. Physics has a collaborative learning environment that I really enjoyed with lots of peer to peer support and lecturers that really want you to understand.

I enjoyed the intense problem solving of physics. The question we ask is "can we do that?", whereas with Philosophy it is "should we do that?" which also offered me a challenge. With both Philosophy and Physics I found that I did a lot of my learning outside of class, including reading for interest and thinking quite hard to prepare for tutorials and labs. In essence, with both subjects it was a matter of learning how to learn and it enabled me to learn how to code fairly easily, which has been one of the crucial tools that I need for the work I do currently. It is not as hard as I thought it would be, but I would suggest learning a little more coding where you can in your undergraduate years - it's where the money is.

The other key thing I learned was understanding systems and how they work and that has also transferred directly into this role, where I have to be able to see the big picture, the way things fit together and how they impact on each other. The Ministry's data is a huge complex system, and essential for evidence-based decision-making.

What I most enjoy about this job is that I can get technical but be making a difference to people's lives at the same time. There's an acceptance in your first job that you can't do everything on day one and that you will grow into it. It's about the fit in the organisation and potential to learn. My advice is, when it comes to applying for jobs or learning new skills, don't say 'no' to yourself before others say 'no' to you. Have a go and you can often be surprised.

Kate Turner

Research Assistant for the Deep South Challenge
Victoria University of Wellington



I returned to do Honours in Physics after completing undergraduate studies in Physics, Mathematics and Philosophy and working for a time in the energy industry as an Energy Analyst and Regulatory Advisor. I developed an understanding of market economics and skills in presenting and facilitating working groups impacted on by industry changes, but I knew I wanted to apply my scientific mind to something with a real-world application and people problems. In my Honours year I focused my research on sea ice, and developed some techniques and methodologies needed for sea ice research. I also chose a special topic in Science Communication to better understand science as a community conversation.

While investigating research funding, I moved into a role as a Research Assistant with Deep South Challenge Engagement programme, hosted at Victoria University. This programme aims to enable New Zealanders make more informed decisions about climate change, utilising improved Earth System Modelling capability.

While in the US presenting my Honours research at a conference I decided to visit universities in Alaska and Wellington, BC and connect with sea-ice researchers with whom I was in contact over email and Skype. I also applied for and was recently granted a Fulbright Science and Innovation Award, which I will use towards my PhD in Alaska. My thesis will be a part of a four-year project, co-lead by the indigenous community of Kotzebue and two research universities, and will focus on physical sea ice growth/melt processes as a mechanism to understand the impacts of ice loss on the Kotzebue community. This work is a collaboration of indigenous and scientific ways of knowing, and I hope to be able to learn from and eventually contribute to this space where understanding culture is integral to doing genuine science.

Physics is really quite beautiful and I personally missed the type of thinking it demanded while I was working in industry. Logical, yet creative. In saying that, everybody is different and Physics is an incredibly powerful degree to have when you do look for a job. You are seen to be someone with strong analytical skills, and these skills cover numerical work, policy analysis and statistics, to name a few. It is one degree with huge value.

Udbhav Ojha

Software Developer
FNZ



Mathematics and the sciences were my strong subjects at school. I remember one day watching a programme on Discovery Channel, where this guy was trying to do a difficult skiing manoeuvre and they stopped the frame in order to calculate whether it was possible for him to come out of the move successfully. I remember thinking, "Wow! Can you create those kinds of models?" Career decisions can also hinge on influential teachers, and a professor in my Master's in Physics programme showed me aspects of statistical mechanics, nuclear and particle physics using modelling, simulation and object orientated programming - so the ICT aspects were exciting.

With a PhD, you need to be driven by the love of your topic over earnings from scholarship or career ambitions. You need to be really curious and be able to delve really deep into the subject. I was offered a number of internships, but the MacDiarmid Institute in Wellington had the research opportunity I was looking for in condensed matter and materials physics, with a strong computational aspect. One, amongst many, of the areas the results of my research can be used is to create clean-burning fuels from separating hydrogen and oxygen atoms of water.

I discovered my current employer at the campus careers expo and got talking to them. I realised that I had the skills they are looking for and was encouraged to apply for their graduate programme. It is a change from the research I was doing in terms of pace and being able to see first-hand the experiences of our users. We are a fintech company and specialise in designing wealth management wrap platforms, write complex financial business logic and create web applications to support our clients, major financial institutions, to manage their investments.

As well as the advanced modelling, simulation and coding skills, I can also bring a different way of thinking to a project team. This includes working closely with business analysts, testers and other members of the project team to produce the best software to do that. Having done some teaching, I also bring the ability to facilitate learning in the teams I work with and break open our thinking to go outside boundaries just as we were required to in physics research.

Harry Warring

Physicist, Vehicle Test Engineer
Rocket Lab



I was not the most academic student at high school, but I enjoyed learning how everything works. This made physics the most enjoyable out of my high school subjects, leading me onto choosing a Physics major for my science degree. Physics breaks the world into manageable pieces and allows you to understand it at a fundamental level which was one of the things I enjoyed most in my studies. This analytical scientific method is also probably the most important skill I gained during my studies. By realising that a problem can be understood by breaking it down into its constituent parts, physics offers those who study it a unique perspective on the world. The understanding physics offers can be incredibly useful and allows technological progress to continue, improving our lives in the process.

My undergraduate degree led to a PhD studying materials at their base level. I had access to state of the art equipment which I used to prepare thin film devices of novel materials, and then look at them in extreme environments of low temperatures and high magnetic fields. The skills and experience I gained during this time working with vacuum systems and cryogenics, as well as modifying and repairing scientific equipment prepared me well for my current work as a test engineer at Rocket Lab. We are currently developing a launch vehicle (rocket) to deliver small satellites into orbit and successfully launched our first test rocket into space earlier this year. My role is to test rocket hardware, understand how it works at a fundamental level, how it can fail, and to feed that information back into the design cycle of the rocket. Physics offers a broad understanding and skill set which helps in this testing and data gathering process.

My main advice for students considering a major in Physics would be to try and enjoy solving problems, and see them as a journey rather than an obstacle.

Krista Grace

Postdoctoral Fellow in
Computational Chemistry and
Physics
New Zealand Institute for
Advanced Study



I've always liked maths and science and my interest has always been on the application side of the disciplines. My love for Physics all started with a marvellous university instructor noticing my intense curiosity about a law of electromagnetism. I was completely enthralled, initially with astrophysics and astronomy. My teacher fed this enthusiasm and sense of wonder, lending me a book that presented some of the great unsolved questions of the world of physics and I changed majors from Engineering to Physics. At undergraduate level I went on to focus on lasers, rather than general physics or astrophysics as by this time I wanted to make a move from the astrophysics side of things as there were too many assumptions made. The study at undergraduate level is more experimental and you need to be prepared to be in the lab a lot.

My first job post-Master's was doing Image Analysis using mathematical and computational techniques. This means tuning an algorithm to get better use of images, with application in crucial areas such as medical imaging. However, I was still looking for that challenge and was constantly reading papers on the side in materials science, a merging of solid-state physics, and chemistry. The PhD opportunity came up as a career change from a focus on the infinite to the microscopic of quantum physics, in particular using and developing computer codes to study the physics that governs material properties.

When you do a PhD in Physics you get to extend your problem-solving beyond what you can imagine in a big-picture way. You need to ask the big questions that no one has asked yet, and contribute something that others haven't. That's real creative thinking. Along with that you need to be self-reliant: you've gone beyond where you are led by a teacher.

In the postdoctorate work I'm doing, I can truly say I'm living the dream. I get this opportunity to run the range from totally practical to intangible. I learn from everything. My research interests are in nanotechnology, in particular nanomaterials with application to renewable energy. Material combinations can be tuned to make better solar energy harvesters from earth-abundant materials that have no impact on the environment. I know it is doable!