readr

# Introduction

This document will tell you about the program on offer at the research education and development retreat in 2017. Most of the workshops assume only general familiarity with undergraduate mathematics and physics, but some will require additional orientation. This document contains all of the material that you will be expected to know beyond common undergraduate knowledge, and instructions for installing software for use in the workshops. If you have any questions or issues at all, email contact@readr.org.au.

The workshop series has been curated to include skills you may not have acquired in your undergraduate degrees. You may find some workshops easy and others challenging, as your backgrounds will vary a lot. If you find the work easy, try to find someone who is struggling and help them. Through teaching material, we come to understand it better. Plus, it's satisfying to help someone solve a problem.

None of the skills you will learn here exist in a vacuum. They all have a place in the process of research and problem solving, and the schedule is constructed to reflect this. It is expedient to gain some understanding of a research problem before plugging in sensors, so you will gain experience making effective estimations based on sensible approximations, and then using python to solve problems in novel dynamic situations. When you do finally start collecting data, you will inevitably deal with calibration issues, noise, and signal identification. You will get hands-on time with real-time audio processing. Extracting information from data is aided by modern computing tools, which you see in workshops on data analysis and machine learning. Once you have a result, you must be sure it is robust and independent of your bias. Humans are very bad at estimation. You will see some examples of this, how statistics can allay some of the troubles, and that they are actually quite user-friendly. The key function of researchers is to collect and communicate new knowledge, and on the second point you will learn how to clearly transmit your research to other scientists.

Working through a PhD is a deeply personal exercise, and will challenge more than just your intellect. By reflecting on the experiences of senior students in an open question and answer session, you will learn about the practicalities of working in a research environment and making the best use of your PhD. Nonetheless, research work can be trying. Maintenance of mental health is crucially important to maintain focus, interest, and vitality. In collaboration with ANU counselling, you are invited to participate in a pragmatic conversation about staying sane in academia. The working culture of academia is constructed by our collective decisions, and the transmission of behaviour is a complex and subtle process. Representatives from ANUFifty50 will lead a critical discussion of the workplace culture of academic science. The first point of cultural commentary is that the demographics of scientific research are not an accurate representation of the demographics in broader society. By explicitly drawing attention to the behavioural conditioning implicit in academic science, you will be better equipped to make a positive change in the lives of your colleagues and dismantle harmful normative behaviours.

Four keynote speakers from the ANU will relate hard-earned lessons from their post-PhD careers in research, both fundamental and applied, and various industrial roles. They will show you what life is like on the "other side" of graduate study, and what possibilities are afforded by completing a PhD.

The last page of this document contains the workshop schedule, which may be subject to change. Below you will find a package you should read before arriving at readr. There are some short activities you should complete as well.

# 1 The Workshops

## Estimation

### Dr Sean Hodgman, ANU

After completing an undergraduate physics degree, most students will have a lot of experience and a fair degree of confidence at solving 'textbook' physics problems. However, such problems are often quite different from those typically encountered in a research environment. Research problems often involve simplifications, approximations and educated guesses at what can safely be ignored, skills that aren't always taught in physics courses. In a research environment, a quick, 'order of magnitude' answer is often much more valuable than a thorough modelling of every aspect of the problem. This workshop will provide students with the necessary skills and experience to give them the confidence to tackle such problems when encountered during their PhD. A range of techniques and tips will be demonstrated through numerous examples of actual research problems.

## Introduction to numerical computing

### Dr Josh Izaac, UWA, Xanadu Quantum Computing

When you began your undergraduate Physics course, you would have come across quantum mechanics in various different guises – from studying the photoelectric effect to long lab sessions viewing atomic spectra. As you progressed through your degree, focus would have then switched to (attempting) to understand the underlying mechanism of quantum mechanics, the ubiquitous Schrödinger equation, by solving the equation in various simple cases such as the infinite square well, finite square well, Harmonic oscillator, and even the Hydrogen atom (simple!). Some of you might even be familiar with more advanced techniques, such as matrix mechanics and relativistic quantum mechanics. Unfortunately, most courses tend to shy away from the most common scenario physics researchers find themselves in during their research – what do we do when we *can't* use our theoretical techniques to solve (or even approximate!) Schrödinger's equation?

In this course, we will introduce some important concepts in numerical computation, applying them to various physics problems along the way. By the end of this course, we will have developed the techniques to solve the one-dimensional Schrödinger's equation in the case of arbitrary potentials. Most importantly, the skillset developed here is applicable to almost every other field of physics — today, numerical computation has rapidly become one of the number one tools in the physicists arsenal.

## Signals

### Dr Josh Machacek, ANU

Nearly all experimental apparatus require the use of cabling. Of utmost importance are signal cables. These cables are typically transmission line cables, which are often referred to colloquially as 'BNC' cables. However, this really only refers to the connector and not the transmission line itself. So, why are transmission lines or 'cabling' so important? You may recall a very high profile case of, 'wait, scratch that, it was a bad cable...' [1]. A bad cable happens more than you might think, but typically only results in your experiment not working. In an effort to give you a bit of help before starting your PhD, and help prevent a high-profile mistake, we are going to discuss a simple method to measure transmission line quality.

Time Domain Reflectometry or TDR is a method in which a pulse is sent down a transmission line. If a defect is present in the transmission line, part of the pulse will be reflected. Information about the defect is encoded into the return pulse and allows the transmission line to be diagnosed, over large distances, without removing the cable from the experiment (or ground). There are a number of good references online which discuss various cable faults and examples of where this technique is used in industry [2,3,4].

Okay, so now you know something about diagnosing cables. Hopefully, you picked up on how a pulse travels in a medium and is reflected from an imperfection in that medium. In a simple sense, this is precisely how sonar and radar work. A pulse of energy, compression wave (sound) or transverse wave (electromagnetic radiation), is emitted in a medium, (water or air), and a range of return signals are observed. Typically, return signals are weak, but information can be extracted. An imperfection, or target, will return the same weak signal for the same input pulse, in the simple case. The return signal can be picked out of random noise (from the environment) because of the time correlation of the return signal with the input pulse. One important piece of equipment that you will likely find in a experimental lab is the lock-in amplifier [5, 6].

## Staying sane in academia

### Andrew Staniforth, ANU counseling

A PhD is a multi-year mental marathon. This mean that like any athlete, PhD students have to take care of and train their brain with healthy behaviors. Managing the challenges of this ultimate test of mental stamina can be made even more difficult with the appearance of struggles such as impostor syndrome, managing a productive relationship with a supervisor and decreased motivation. Research problems often have no well-defined solution, and searching for one can be protracted and tiring, especially when a high-performance sprint is periodically required. This workshop aims to give you a vital set of skills that will last not only the course of your higher-degree research, but well into your working life (whatever field you choose). To help you stay sane, this workshop will give you guidance on resources, help, and ingredients.

## Machine learning

### Dr Michael Hush, UNSW

What is machine learning? What's hype and what's real? When will us meatbags be eliminated in the glorious silicon revolution? These questions, and more useful ones, will be addressed in this tutorial. We will look at recent application of machine learning to problems in research physics. We will also work through some introductory problems of applying artificial neural nets to solve some complex problems.

## Measurement & Uncertainty

### Dr Geoff Campbell, ANU

> *"...as we know, there are known knowns; there are things we know we know. We also know there are known unknowns; that is to say we know there are some things we do not know. But there are also unknown unknowns – the ones we don't know we don't know."*
> —Donald Rumsfeld

Keeping track of uncertainties is quantifying the known unknowns associated with any measurement. We need to know, or guess, how well a measured outcome reflects the underlying reality of the thing we're trying to measure. Sometimes this is easy, sometimes less so. In general, there's no one strategy that captures every way in which we could be uncertain about our measurements, and yet, there's a need to do exactly that. To be able to quantify the uncertainty in quantities that are calculated using a number of independent measurements, there needs to be a standard way to characterize and combine uncertainties.

In this workshop we'll discuss why we need uncertainty analysis. We'll consider the challenges of assessing potential sources of error in experiments, how cognitive biases can trick even most analytic minds into false conclusions, and how we can use statistical analysis to avoid it. To gain an understanding of error propagation, we'll initially approach the problem rigorously and look at how probability distributions can be propagated through formulas to find uncertainties in derived quantities. From there, we'll discuss the assumptions that lead from a complete statistical approach to the standard error propagation model and consider when standard error propagation applies.

Equipped with a solid understanding of error analysis, we'll examine some recent major discoveries in physics and consider how the significance of the experimental outcomes was assessed. This will lead us into the concept of hypothesis testing and how it can be used to assess significance in experimental data or misused to support incorrect conclusions.

## Equity and bias in STEM

### Georgina Ims, ANU Fifty50, ANU CECS

STEM research institutions in Australia face major accessibility and retention issues, resulting in limited diversity of thought, perspective and experience in research environments. Being of a particular gender, race, ethnicity, sexual orientation, socioeconomic status, or age (among other factors) can present major barriers to people at every stage of a STEM career. These barriers are not 'someone else's problem' – many of them exist due to culture, and are perpetuated by individual behaviour. Everyone in STEM has the responsibility and opportunity to create cultural change through actively making STEM environments more inclusive.

The ANU Fifty50 Equity and Accessibility in Research Workshop will explore what equity is, and why striving for it is important. The barriers that exist in a gender context in STEM will be discussed, particularly the factors that contribute to the 'leaky pipeline'. We will consider the role of unconscious bias in influencing thought and behaviour, and discuss what measures can be taken to mitigate its effects. Finally, strategies to make small behavioural changes that foster an inclusive and accessible STEM environment will be presented.

## Data analysis: Finding superheavy elements

### Dr Kaitlin Cook, ANU

How are new elements discovered? In this workshop, we will analyse data from an experiment to find candidate nuclear reactions to form new superheavy elements. These nuclear reactions take place in femtometers ($10^{-15}$ m) and take only zeptoseconds ($10^{-21}$ s). You will learn how you can use simple physics principles together with cleverly designed experiments to gain deep insights into these physics processes that are otherwise inaccessible. In doing so, you will gain skills in multi-variable analysis that you will be able to apply to your own research.

## Writing

**Dr Rose Ahlefeldt, ANU**

Undergraduate science courses focus on teaching you, well, science. But as you go further on in your studies and in your career, it becomes important to not only understand your science, but to be able to communicate your knowledge to others. If you do a PhD, you will have to write a thesis, write papers, give seminars. Further into an academic career, you need to win grants to be able to fund your research. If you move into industry, the public service, or almost any other area you will likely have to write reports and give presentations on your work. Good communication skills are often a specific selection criterion for jobs across all these industries.

The basic principles of effective communication are the same for all these different science communication tasks.This workshop will show you what good science communication looks like by using examples (good and bad) largely taken from published scientific literature. We'll look at common problems and how to fix them, with the aim to provide you with tools to improve your own writing and presenting skills. We'll focus mostly on formal science writing (papers, theses), but will also talk about oral presentations.

# 2 Preliminary reading

## Introduction to numerical computing

### Outcomes

There are four main components commonly required in scientific computing:

1. **Theoretical modelling:** mathematical equations used to model the world around us are identified and applied to the specific problem at hand.
2. **Numerical Methods:** numerical algorithms are then applied to the system at hand, in which the system is 'discretised' and solved via an iterative procedure or 'recipe'.
3. **Programming:** the numerical algorithm is then transcribed to a set of instructions to be evaluated by a computer.
4. **Data visualisation and interpretation:** often the most important step of scientific computing, this involves checking for systematic and numerical error, determining the significance of the results, and choosing a relevant approach to presenting the results.

This is a *lot* to cover in 3 hours! Furthermore, you all come from diverse backgrounds — some of you may not have programmed much before, whilst some of you will feel completely at home compiling and using UNIX. Due to time constraints, we will focus mostly on numerical methods, and I will be providing interactive notebooks for you to work through to provide guidance and code snippets.

I'll briefly go through the four outcomes listed above, and describe the objectives, tools, and requirements.

- **Theoretical modelling objective:** Problems will focus on ordinary differential equations (ODEs); both initial value problems (IVPs: for example, atomic decay and Newton's equations) and boundary value problems (BVPs: the Schrödinger equation).

These are all systems you should be familiar with from your undergraduate course. If you are a bit hazy, don't worry! I'll provide quick refreshers before tackling the problems. As the focus is on numerical results, solving them analytically will not be required. However, it is helpful if you brush up on their general solutions and behaviour.

- **Numerical methods objective**: Key techniques we will cover include root finding, numerical differentiation and ODE solving, and numerical integration. We will also consider numerical error and stability, **a really important** part of numerical computation.
- **Programming objective**: We will solve these problems using Python 3, and the Jupyter notebook environment.

Python is becoming increasingly popular among scientists for several important reasons; it's easy to learn, it's open source and cross-platform, there are a multitude of available scientific libraries for Python, and it's interactive, making prototyping faster and easier. Furthermore, it doesn't require compilation to run. In this course, I will provide interactive Jupyter notebooks to provide explanations, images, and a place to run Python code. **Note: knowledge of Python (or programming in general) is not required!**

- **Data visualisation objective**: The Jupyter notebooks I provide will contain code snippets for plotting your solutions using the `matplotlib` Python plotting library.

However, as we are not focusing on data visualisation here, feel free to use software of your choice for plotting your results — whether that's Excel, Mathematica, or Matlab.

Requirements As you will be using your own laptop, here are is a list of software packages you will need to have installed and ready to run.

- **Python 3**
  - On Windows and MacOS the best way to install Python is via Anaconda. Make sure you install Python 3.6, and not 2.7.
  - On Linux, consult with your distribution documentation to see if Python 3 is already installed/how to install it. If you're using Ubuntu, it can be installed using apt-get: `sudo apt-get install python3`
- **NumPy, SciPy, matplotlib, and Jupyter notebook**
  - On Windows and MacOS, using Anaconda: these come with Anaconda.
  - On Linux, these can be installed using your package manager, compiled from source, or installed using `pip`.

And that's it! Try running the Jupyter notebook environment to get a feel of how it works — it can be launched by opening the Terminal (MacOS/Linux) or the Command Prompt (Windows) and running `jupyter notebook`. Here is a list of interesting Jupyter notebooks. I will also be providing an introduction to Python Jupyter notebook as pre-reading before the course.

## Data analysis: Finding superheavy elements

This document is designed to give you some theoretical background in nuclear reactions, as well as an insight into one experimental approach to measuring nuclear reactions, before the workshop. If you've done a course in nuclear physics, many of these concepts will be familiar to you. In that case, please consider this a refresher.

### Nuclear reactions

The positively charged centre of an atom – the atomic nucleus – is composed of protons and neutrons. When two nuclei collide in a nuclear reaction, two fundamental forces are relevant – the long-range Coulomb force, repelling the nuclei, and the short-range attractive strong (nuclear) force. These interactions can be described by the internuclear potential, shown schematically in Fig. 1. At large distances $r$, the Coulomb interaction dominates the nuclear potential. When the nuclei become close enough to almost touch $r \sim r_B$, the nuclear force begins to play a role, forming a local maximum $V_B$ in the internuclear potential. This is known as the Coulomb barrier.

Depending on the trajectory of the colliding nuclei, and their total kinetic energy, two different things can occur:

1. The repulsive Coulomb force can cause the two nuclei to be diverted from their collision path. These nuclei may end up in an excited state as a result of this interaction, but they never get close enough to touch.

2. The two nuclei have close enough trajectories and sufficient kinetic energy to overcome the Coulomb force. In this case, they get close enough for the strong force to take effect. When this happens, **nuclear reactions** occur, resulting in changes in the compositions of the colliding nuclei (i.e. number of protons or neutrons). The degree of change depends mainly on how close the nuclei get. When the nuclei get very close, nuclear fusion can occur. In a purely classical picture (which we will be sticking with for this workshop), a projectile nucleus needs an energy equivalent to $V_B$ to overcome the barrier and fuse with the target nucleus.

It is important to note that in any given experiment, all trajectories are sampled – from a head on collision to one where the nuclei pass so far away that their trajectories are not disturbed. Therefore, all possible nuclear reaction outcomes (depending on the energy and projectile-target combination) will occur. This means that while you may be only interested in on reaction outcome (say, fusion), you typically cannot study this outcome in isolation. Indeed, different reaction outcomes may compete with each other – this becomes important when producing new elements.

### Fusion: Forming new superheavy elements

The way we produce new superheavy elements is through nuclear fusion. For example, element 114, Flerovium, was first produced at JINR in Russia by the reaction

$$^{48}_{20}\mathrm{Ca} + ^{244}_{94}\mathrm{Pu} \rightarrow ^{292}_{114}\mathrm{Fl}^* \quad (1)$$

That's a $^{48}_{20}$Ca beam colliding with a $^{244}_{94}$Pu target to produce $^{292}_{114}$Fl in an excited state (indicated by the $^*$). Element 118, Oganesson, was first produced at JINR in Russia (in collaboration with Lawrence Livermore National Laboratory) by

$$^{48}_{20}\mathrm{Ca} + ^{249}_{98}\mathrm{Cf} \rightarrow ^{297}_{118}\mathrm{Og}^* \quad (2)$$

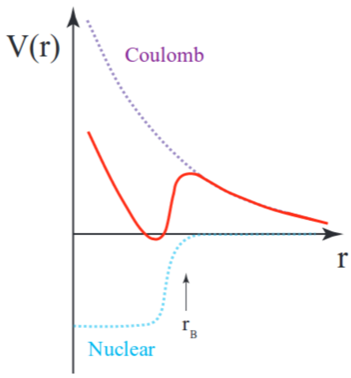


Figure 1: A sketch of the nuclear potential (red line) plotted as a function of internuclear separation $r$. This potential is the sum of the repulsive Coulomb potential (purple dots) and the attractive nuclear potential (blue dots)

Oganesson is the heaviest element to be produced so far. The race is now on to discover elements 119 and 120. The excited nucleus has to shed this energy somehow. There are two ways to do this: by particle evaporation, or by fission. In particle evaporation, the nucleus will shed energy by releasing one or more neutrons (in this mass region), giving as a final product, say:

$$^{48}_{20}\mathrm{Ca} +^{249}_{98}\mathrm{Cf} \rightarrow^{297}_{118}\mathrm{Og}^{*} \rightarrow^{294}_{118}\mathrm{Og} + 3\mathrm{n}. \tag{3}$$

This is shown schematically in Fig. 2(a). $^{294}_{118}\mathrm{Og}$ is your final product, which subsequently decays via $\alpha$ emission. In this case, you end up with very happy experimentalists. In total, five (perhaps 6) such decays have been observed. These reactions are very very very rare. $2.5 \times 10^{19}$ $^{48}\mathrm{Ca}$ atoms were used before the first decay of Og was seen. Far more frequently, fission will occur. In this case, the excited compound nucleus will split into two (rarely three) pieces of differing sizes, shown schematically in Fig. 2(b). The degree of competition between fusion-evaporation and fusion-fission depends on the excitation energy and angular momentum of the compound nucleus. However, **the presence of fission indicates the formation of a compound nucleus**. Thus, if you want to figure out the best way to form the next superheavy element, the best approach is to find a reaction that maximises the probability of capture – so you look at fission events. It's just not feasible to start out just looking for fusion-evaporation!

One thing that's common between the reactions producing elements 114 and 118 (and indeed, elements 113,115,116 and 117 too) is the use of $^{48}\mathrm{Ca}$ as the projectile. That's because $^{48}\mathrm{Ca}$ is especially useful for producing superheavy elements (for reasons we'll discuss later, and in the workshop). So in principle, to make a new superheavy element, you've just got to increase the number of protons in your target by one. The trouble is that the heaviest element you can sensibly make into a target is Californium (Cf), element number 98. We've run out of options to use a $^{48}\mathrm{Ca}$ beam! This means that to get to element 119 and 120, we have to use a beam with more protons.

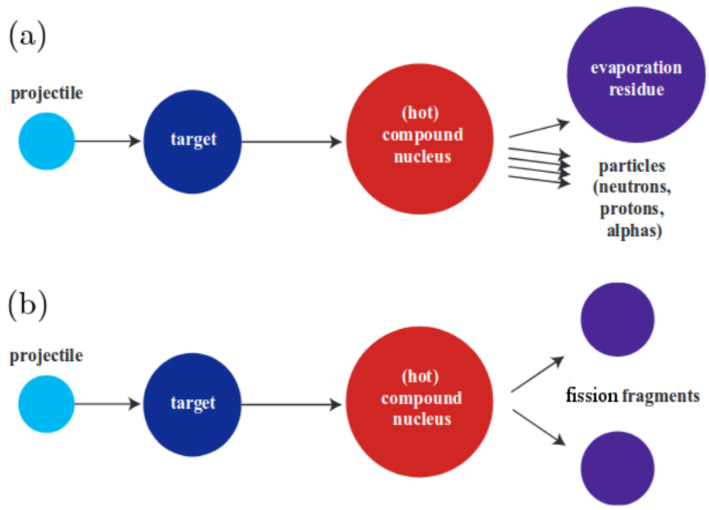


Figure 2: Schematic (not kinematically accurate) diagram of (a) fusion-evaporation and of (b) fission.

There's no shortage of elements with more protons than calcium, so what beam-target combination should we choose? The choice comes down to many factors, but an very important one is choosing a reaction that maximises your chance of forming that hot compound nucleus. This means that you need to make a choice that minimises a reaction outcome that we haven't talked about yet – quasifission.

### Quasifission: Reactions competing with superheavy element creation

Quasifission, as the name suggests, is a reaction outcome that looks a bit like fission. Quasifission occurs when the colliding nuclei stick together for *not quite* long enough for a compound nucleus to form, and rotate a little bit (thanks to conservation of angular momentum) before separation. As the nuclei do stick around for a little while, there is a lot of mass transfer between the colliding fragments. It turns out that the amount of sticking time (and hence the number of rotations the nuclei undergo) is linked to the amount of mass transfer – very short sticking times correspond to very little mass transfer, and very long sticking times correspond to complete mass transfer, i.e. compound nucleus formation. The difference between fission and quasifission is shown schematically in Fig. 3.

Quasifission is one of the most important reactions competing with compound nucleus formation. It turns out, due to the structure and neutron-richness of $^{48}$Ca, reactions with this projectile show less quasifission. Thus, to choose the reaction forming the next superheavy element, we have to figure out which reactions show mostly fission, and which show mostly quasifission. Since the amount of mass transfer and number of rotations is a signature of quasifission vs fission, we want to measure both the mass of the fragments and the angle at which they are flung out from the target.

The task of this workshop is the analysis of nuclear reaction data to first isolate events corresponding to fission and quasifission and to determine their masses and angles. This data was

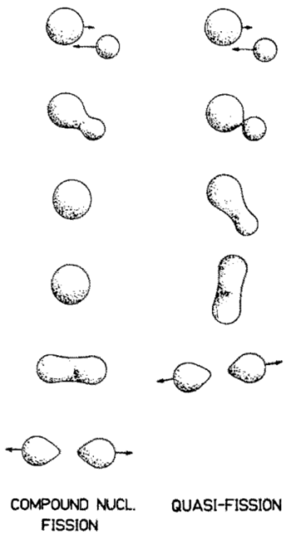


Figure 3: Sketch of fission following compound nucleus formation (left) and quasifission (right).

recently taken at the Australian National University, using the Heavy Ion Accelerator Facility. You can take a (work in progress!) virtual tour of the facility here: http://people.physics.anu.edu.au/~ecs103/tour/.

What you need to do before the workshop

- Have ROOT installed – the organisers will provide this to you.
- Read the appendix to the attached paper, found on page 13 of this pdf. This will give you an idea of how to use the measured velocity vectors for two fragments to determine their relative masses. We've included the rest of the paper for completeness (and for the keen reader!) but you are not expected to have read it.

## Measurement & uncertainty

### Programming elements

The discussions will be illustrated by working through examples in Python. These will use the Numpy package to create probabilistic data sets and the matplotlib package to visualise the results. We'll cover the basics of using Monte Carlo methods, computational methods that use random numbers, to simulate experimental data that we can analyse. To get the most out of the workshop, be sure to brush up on Python so you're comfortable working with numerical datasets as well as plotting data using matplotlib.

### Reading Assignment

To gain an appreciation for statistical uncertainty analysis done right, have a read trough the paper "Strong Loophole-Free Test of Local Realism", Lynden K. Shalm et. al. Phys. Rev. Lett. **115**, 250402 (2015) and the supplementary material. The paper makes an extraordinary claim: that the world around us is not governed by local realism. It demonstrates that experimental evidence refutes the hypothesis that that "nature respects local realism". To make this claim, extraordinary evidence is needed. The paper provides rigorous statistics to argue that chance of the result being a statistical fluke is vanishingly small.

You can just skim the paper (or read in-depth if it piques your curiosity) to understand the context for why the experiment is important and why extremely careful analysis was needed. Then, read through the first section of the supplementary material "Methodology for statistical inference and hypothesis testing". The supplementary materials explains what methods were used to extract valid statistics from the data and ensure that the cognitive biases of the experimentalists could not influence the results.

### Scientific writing and communication

In preparation for the workshop, there are two things you should do:

1. Write a 300-500 word article on a research project you have done, such as your Honours project or an undergraduate research project. If you haven't yet done any research projects, choose a published academic article, and describe their work. Your article should be written for general physics audience (i.e. readers with an undergraduate education in physics). It should explain the context and motivation for the project, as well as what you found out and what implications your results have. You can look articles in Physics Today for examples of this type of writing. During the workshop, you will have a chance to discuss your article with other students and revise it based on what you learn.

2. Bring in a substantial piece of writing that you have done in the past, such as a lab/project report, or a thesis chapter. We will use this to learn how to analyse your own writing.

Optional:

1. In any reading you do over the next month, consider what makes for good and bad science writing and see if you can identify any examples. If you do, bring them along. To give you some things to look for, ask yourself: Is the language easy to understand? Is the meaning clear? Are there jumps in logic (you can't see how one concept links to another)? Are their statements justified or referenced?

2. Consider reading these two classic books on good writing: "On writing well" by William Zinsser, and "The elements of style" by Strunk and White. Both describe simple principles for writing clearly. They are both fairly short and certain editions are available free online.

SCHEDULE

| | Sunday | Monday | Tuesday | Wednesday | Thursday | Friday | Saturday | Sunday |
|---|---|---|---|---|---|---|---|---|
| | 10 Dec 17 | 11 Dec 17 | 12 Dec 17 | 13 Dec 17 | 14 Dec 17 | 15 Dec 17 | 16 Dec 17 | 17 Dec 17 |
| | Arrival day | | | | | | | Check out |
| 08:00 | | Breakfast | Breakfast | Breakfast | Breakfast | Breakfast | | |
| 09:00 | Depart Canberra | **Estimation** | **DAQ Hackathon** | **Machine Learning** | **Statistics** | **ANU Fifty50** | Breakfast | Breakfast |
| 10:00 | | | | | | | | |
| 11:00 | | | | | | | **Writing** | |
| 12:00 | Arrive Kioloa | Free hour | Free hour | Free hour | Free hour | Free hour | | Depart Kioloa |
| 13:00 | Lunch | Lunch | Lunch | Lunch | Lunch | Lunch | Lunch | |
| 14:00 | Orientation | **Numerical computing** | **Staying Sane** | **Free Afternoon** | **Q&A** | **Data Analysis** | Discussion session | |
| 15:00 | Troubleshooting | | | | | | Free afternoon | Arrive Canberra |
| 16:00 | | | | | | | | |
| 17:00 | Welcome address | Free hour | Free hour | | Free hour | Free hour | | |
| 18:00 | Dinner | Dinner | Dinner | Dinner | Dinner | Dinner | Dinner | |
| 19:30 | Evening activity | Keynote: nanda | Keynote: Anis | Keynote: robins | Keynote: Jagadish | | Closing address | |

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