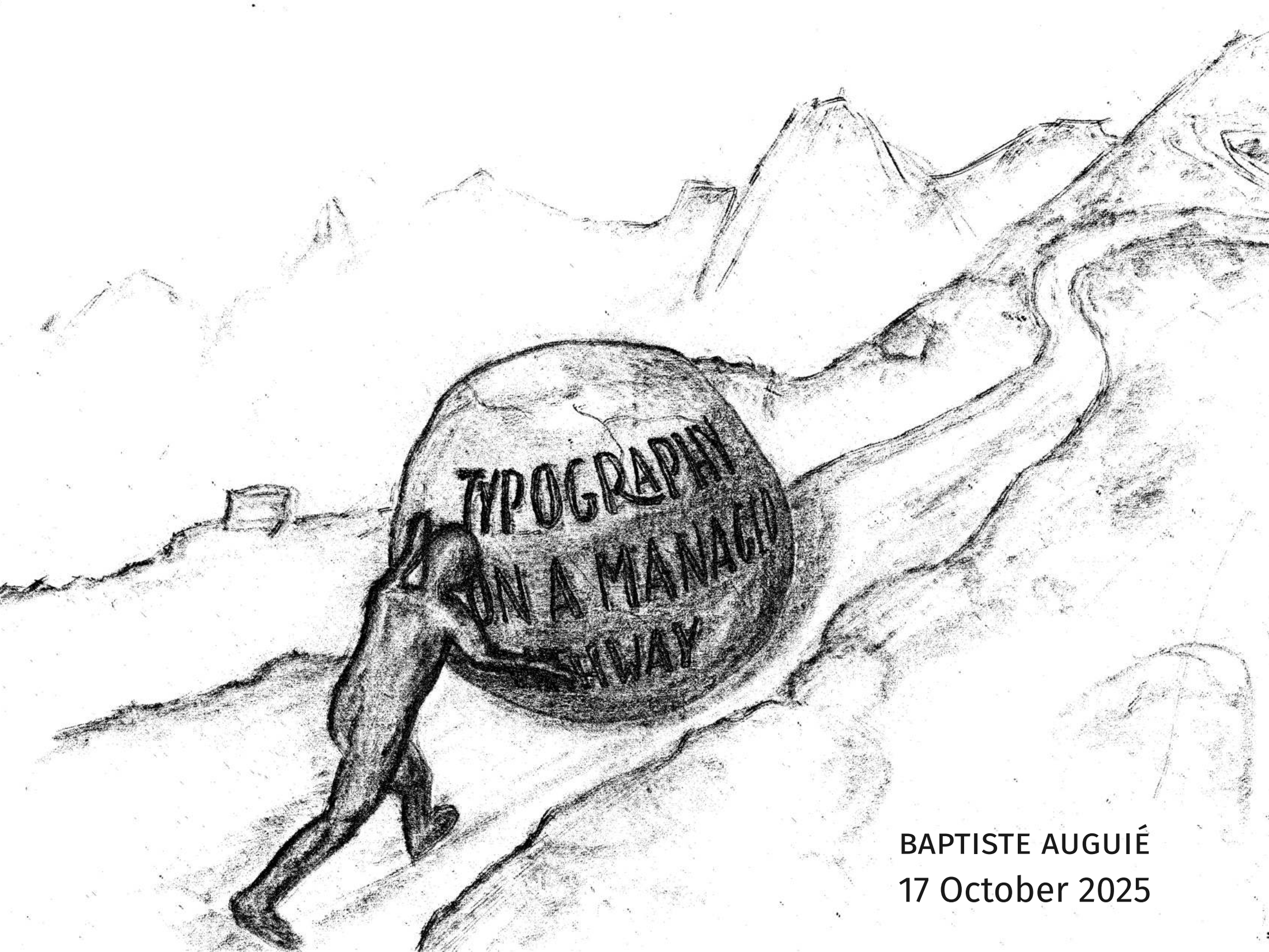


BAPTISTE AUGUIÉ

17 October 2025

OUTLINE

1. Teaser
2. Examples, learning curve
3. Hands-on, get the ball rolling


```
42  var camera = new THREE.PerspectiveCamera(20, width / height, 0.01, 1000);
43
44  camera.position.z = 10;
45
46  var renderer = new THREE.WebGLRenderer();
47  renderer.setSize(width, height);
48
49  scene.add(new THREE.AmbientLight(0xeeeeee, 1));
50
51          var sphere = createSphere(radius, segments,'typography_managed.png');
52      //    sphere.rotation.x = Math.PI/2;
53          scene.add(sphere);
54
55
56  var controls = new THREE.TrackballControls(camera);
57
58  webglEl.appendChild(renderer.domElement);
59
60  render();
61
62  function render() {
63    controls.update();
```

The enjoyment of one's tools is an essential ingredient of successful work.

— Donald Knuth

The tools we use have a profound and devious influence on our thinking habits, and therefore on our thinking abilities.

— Edsger Dijkstra

VICTORIA UNIVERSITY OF WELLINGTON
TE HERENGA WAKA

Course Outline Editor Search ' 202301

Search Criteria

Approval Status: All

Subject Code:

Course Number Low: **urse Number High:**

Part of Term:

Offered / Not Offered:

Faculty:

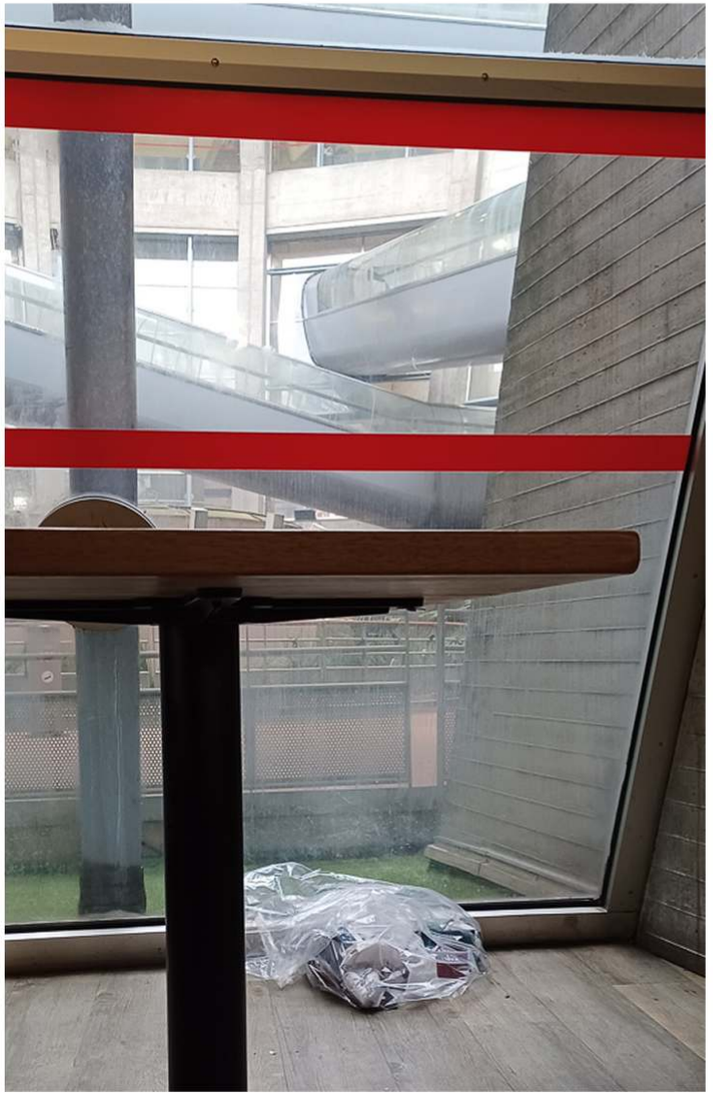
School:

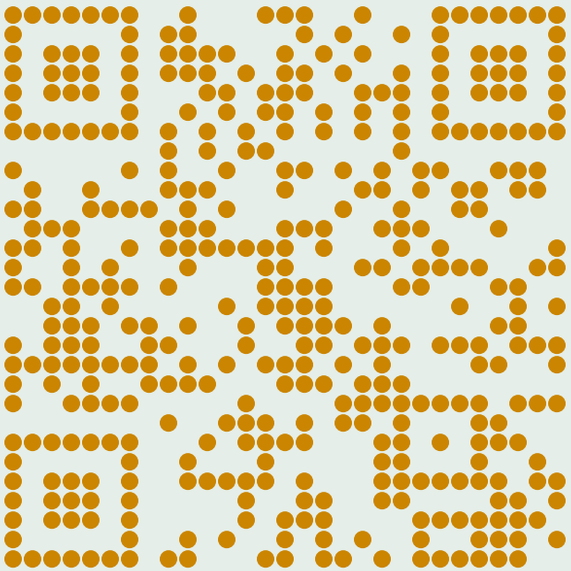
Search | Clear | Download Searc

- ✓ All
- ACCY
- ACTS
- AFIN
- AHTY
- AIML
- ALIN
- ANFX
- ANTH
- ARCH
- ARCI
- ARTH
- ARTS
- ASIA
- ATEN
- BBSC
- BILD
- BIOL
- BMAR

Does **not** bring me joy
or sustain neurons

A TEA ANALOGY





tinyurl.com/managed-typos

PART I: TEASER

wgtn.ac.nz/api/sqc/courses/get

www.wgtn.ac.nz/api/sqc/courses/getCourseByCodeAndYear?c

Data Headers

Collapse All Expand All Filter JSON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  canvasSectionId:  "202501.CHEM310.36115"
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  offeringStartDate:  "2025-02-24"
  offeringEndDate:  "2025-06-22"
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    1:  "2026"
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  shortDescription:  "Explore the structure and reactivity of molecules
properties and applications. The course discusses s
advanced technologies.  "
  description:  "<p><span><span>Explore the structure and reactivit
reactivities, properties and applications. The cour
applications in advanced technologies.</span> </spa
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prerequisites:
  entry:
    restrictions:  "any of CHEM 302, 303 or CHEM 311, 312 in 2024"
    doubleLabelled:  ""
    corequisites:  ""
    prerequisites:  "CHEM 210 or (CHEM 202 and CHEM 203);"
```


AutoSave 2025 SCPS UG course list

Home Insert Draw Design Layout Comments Reviewing

Paste Font Paragraph Styles Dictate Sensitivity Add-ins Editor Copilot

300-LEVEL COURSES

CHEM 307 CRN 36112 ADVANCED EXPERIMENTAL TECHNIQUES 20 PTS 1/3
Prerequisite: CHEM 207 (or one of CHEM 205, 206)
Restrictions: CHEM 305 or CHEM 306

Refine and expand your experimental and computational skills, exploring practical aspects of chemistry. Choose to build techniques across the breadth of chemistry or focus on medicinal chemistry related areas (depending on your individual interests and background). You will develop synthetic, computational and instrumental analysis skills, and investigate principles of measurement. You will also develop communication skills through the presentation of technical information and data in written, digital and oral formats.

CHEM 308 CRN 36113 CHEMISTRY OF LIFE: MOLECULES AND MECHANISMS 20 PTS 2/3
Prerequisite: CHEM 208 (or CHEM 201)
Restrictions: CHEM301

Explore the structure and reactivity of organic compounds. You will learn about molecular tructure and reactivity through spectroscopy, reactions of carbohydrate compounds, pericyclic chemistry, mechanistic principles and retrosynthesis.

CHEM 310 CRN 36115 REACTIVITY, MOLECULES AND MATERIALS 20 PTS 1/3
Prerequisites: CHEM 210 (or CHEM 202 and 203)
Restrictions: CHEM 302, 303 or CHEM 311, 312 in 2024

Explore the structure and reactivity of molecules and materials. You will learn about molecular structures, material structures, and their reactivities, properties and applications. The course discusses structure-property relationships as a foundation towards molecular reactivities, and materials applications in advanced technologies.

CHEM 311 CRN 36116 CHEMISTRY OF MATERIALS 20 PTS 1/3
Prerequisites: CHEM 202,
Restrictions CHEM 222, CHEM 302, 322, 341

This course will enable students that lack the full prerequisites for CHEM 310 to do the inorganic and materials sections of CHEM 310, in combination with a directed individual study component. The course explores the structure and reactivity of molecules and materials. You will learn about molecular structures, material structures, and their properties and applications. The course discusses structure-property relationships, and materials applications in advanced technologies.

CHEM 312 CRN 36117 CHEMICAL REACTIVITY OF MATERIALS 20 PTS 1/3
Prerequisites: CHEM, 203
Restrictions: CHEM 222, CHEM 302, 322

This course will enable students that lack the full prerequisites for CHEM 310 to do the reactivity and materials sections of CHEM 310, in combination with a directed individual study component. The course explores the structure and reactivity of molecules and materials. You will learn about molecular structures, material structures, and their properties and applications. The course discusses structure-property relationships as a foundation towards molecular reactivities, and materials applications in advanced technologies.

8

Kara Eaton Deleted: CHEM 309 BIOLOGY AND MEDI

Kara Eaton Deleted: →→→CHEM Prerequisite:→CHEM

Explore the use of che biochemical pathways pharmaceutical drugs. and synthesis of chem medicinal chemistry, c an introduction to synt

Kara Eaton Deleted: 20

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Kara Eaton Deleted: ; C

Page 7 of 18 4700 words Focus

School of Chemical and Physical Sciences

CHEMISTRY UNDERGRADUATE COURSES

›› 2025

Contact

School of Chemical and Physical Sciences — *Te Wānanga Matū*
Laby Building, Kelburn Campus
04 463 5335
scps@vuw.ac.nz
www.wgtn.ac.nz/chemistry

CHEMISTRY

Chemistry is everywhere. It is fundamental to all living beings, physical processes, materials and the environment. Chemistry underlies all the functions of the human body, our food, the consumer goods we use, the buildings we live and work in, the energy we generate and consume and the air we breathe. Understanding chemistry is the basis for understanding the function and structure of all of these, and also for developing new materials, pharmaceuticals, consumer products, technologies and processes to enhance our lives.

MAJOR REQUIREMENTS FOR CHEMISTRY

- CHEM121, CHEM122; 15 points from (ENGR121, MATH100-199, PHYS101, 142-145 , QUAN111), 15 points from (BIOL111, BMSC117, BTEC101, ESCI111, 112, GEOG114)
- CHEM201, CHEM202, CHEM203; one of (CHEM205, CHEM206)
- 60 points from (CHEM301, CHEM302, CHEM303, CHEM305, CHEM306)

ENTRY TO 100-LEVEL CHEMISTRY COURSES

Advanced entry
If you have achieved 16 credits in Chemistry at NCEA Level 3 (which includes at least an achieved grade in two external achievement standards), you may enter CHEM121 in Trimester 1 or 2, or CHEM122 in Trimester 2.

Intermediate entry
If you have fewer than 16 credits in Chemistry at NCEA Level 3 you will star: with CHEM113 in Trimester 1. Successful completion of this course will allow you entry into CHEM121 and 122.

Novice entry
If you have not studied Chemistry to at least NCEA Level 2 you are strongly advised to take CHEM191 in trimester three (the summer trimester) (see page 4).

WHO TO CONTACT

All enquiries about undergraduate chemistry courses should be directed to the Chemistry Programme Director, A/Prof Mattie Timmer (Mattie.Timmer@vuw.ac.nz).

100-LEVEL COURSES

CHEM 113 | CRN 17147 | Concepts of Chemistry | 15 PTS | 1

Prerequisites: none
Restrictions: CHEM114, 115, 121, 122

CHEM113 investigates electronic structures and properties of atoms, bonding and periodic trends. This knowledge will be applied to chemical processes including equilibria, redox reactions, transformations of acids and bases and organic reactions leading to an understanding why reactions occur. You will study the properties of organic compounds including nomenclature, isomerism, and the identification and reactivity of organic functional groups.

CHEM 121 | CRN 35058 / CRN 35059 | Chemistry of Life | 15 PTS | 1 / 2

Prerequisites: CHEM113 or 16 NCEA Level 3 Achievement Standard credits in Chemistry including 2 external standards, or equivalent background
Restrictions: CHEM114

CHEM121 is designed for you to understand fundamental chemistry and how it is applied to the biological sciences. This course will cover core chemistry topics including principles of atomic and molecular structure, chemical bonding and reactivity, thermodynamics and kinetics. You will explore the application of chemistry in biologically relevant systems.

CHEM 123 | CRN 35060 | Chemistry of Matter, Energy and the Environment | 15 PTS | 2

Prerequisites: CHEM113 or 16 NCEA Level 3 Achievement Standard credits in Chemistry including two external standards, or equivalent background; MATH132 or 12 Achievement Standard credits NCEA Level 3 Mathematics including one of 91575, 91577, 91578 or strongly recommended: 91579.
Restrictions: none

CHEM122 considers the chemical structure and properties of matter and uses this knowledge to explore the energetics of chemical processes and how this relates to the modern energy landscape. You will then apply this knowledge to investigate the chemistry of environmental systems. A central theme that is embedded within all topics is how chemical technologies can be used for our sustainable future.

CHEM 191 | CRN 23006 | Introductory Chemistry | 15 PTS | 3

Prerequisites: none
Restrictions: CHEM113, 114, 121, 122

This summer bridging course provides basic chemical concepts and laboratory skills as a preparation for the study of chemistry at university level. It is designed for those with little or no background in chemistry or to be a refresher course for those who have studied chemistry in the past. In this course you will: study the big ideas of science and chemistry, explore the fundamental building blocks of matter, and the connections between energy and reactions. You will also investigate these concepts whilst building your practical skills over a three day block in the laboratory.

SCIE 105 | CRN 35091 | The Molecular Science of Life | 15 PTS | 1

Prerequisites: none
Restrictions: none

Explore the molecular basis of human health and everyday life. You will learn about atomic and molecular structure and how this relates to the function of blood. Topics include electrolytes and osmolarity, blood group determinants, gas transport, blood pH, the molecules and chemistry of blood tests, and metabolic imbalances that lead to diseases that are commonly screened for using blood. This course is designed to support students from a range of backgrounds, including the health sciences. No previous chemistry experience needed. This course can be taken fully online, although in-person workshop sessions will be provided to assist with student learning.

SCIE 107 | CRN 36125 | The Molecular Brain | 15 PTS | 1

Prerequisites: none
Restrictions: none

In this course you will explore the molecular basis of the brain. You will learn about atomic, molecular, and cellular structures, and how all three components are critical to understanding how the human brain 'thinks'. You will learn about how the body makes molecules, and how drugs and neurotransmitters interact with receptors to affect neurological processes. Brain imaging and the molecular basis of diseases of the brain will also be discussed. This course is designed to support students from a range of backgrounds. No previous experience in chemistry or biology is needed.

200-LEVEL COURSES

CHEM 207 | CRN 36108 | Experimental Chemistry and Spectroscopy | 20 PTS | 2

Prerequisites: 15 points from CHEM121, 122 (or 114, 115)
Restrictions: CHEM205 or 206

Chemistry is a science embedded within the physical world. In this practical, laboratory-based course, you will gain hands-on experience in modern chemical experimental approaches. You will develop skills in safe chemical handling, using and analysing instrumental data, and will link macroscopic observation with the microscopic world of chemicals. Additionally, workshops and computer simulations will supplement your learning in how to interpret complex data patters to identify molecules and their behaviours at the atomic scale.

CHEM 208 | CRN 36109 | Chemistry of Life: Organic, Biomolecular and Medicinal Chemistry | 20 PTS | 1

Prerequisites: 15 points from CHEM121 (or 114);
Restrictions: CHEM201

Explore the structure and reactivity of organic and biomolecular compounds pertinent to metabolic processes and medicines. You will learn about molecular structure, reaction mechanisms, and spectroscopy, and the application of these concepts to the chemistry of alkene, carbonyl, alkyl, and aromatic compounds. The relevance of this chemistry to drug development and understanding the molecular foundations of living systems will be exemplified.

CHEM 210 | CRN 36111 | Chemistry: Matter and Reactivity | 20 PTS | 2

Prerequisites: CHEM122 (or 114);
Restrictions: CHEM202 or 203

Explore key topics for understanding chemical systems; from molecules to materials, their reactions, changes and transformations. Gain a fundamental ramework for how and why molecules/materials exist in the forms they do. Explore how energy and light are important to chemical systems and chemical reactivity. Understand the reactions molecules/materials undergo, and the reasons, dynamics and 'why' of chemical change. Real-world examples illustrate chemical applications.

300-LEVEL COURSES

CHEM 307 | CRN 36112 | Advanced Experimental Techniques | 20 PTS | 1

Prerequisites: CHEM207 (or one of CHEM205, 206)
Restrictions: CHEM305 or CHEM306

Refine and expand your experimental and computational skills, exploring practical aspects of chemistry. Choose to build techniques across the breadth of chemistry or focus on medicinal chemistry related areas (depending on your individual interests and background). You will develop synthetic, computational and instrumental analysis skills, and investigate principles of measurement. You will also develop communication skills through the presentation of technical information and data in written, digital and oral formats.

CHEM 309 | CRN 36114 | Chemical Biology and Medicinal Chemistry | 20 PTS | 2

Prerequisites: CHEM208 (or 201)
Restrictions: none

Explore the structure and reactivity of organic compounds. You will learn about molecular structure and reactivity through spectroscopy, reactions of carbohydrate compounds, pericyclic chemistry, stereoselective reactions and retrosynthesis.

CHEM 310 | CRN 36115 | Reactivity, Molecules and Materials | 20 PTS | 1

Prerequisites: CHEM210 or (CHEM202 and CHEM203)
Restrictions: any of CHEM302, 303 or CHEM311, 312 in 2024

Explore the structure and reactivity of molecules and materials. You will learn about molecular structures, material structures, and their reactivities, properties and applications. The course discusses structure-property relationships as a foundation towards molecular reactivities, and materials applications in advanced technologies.

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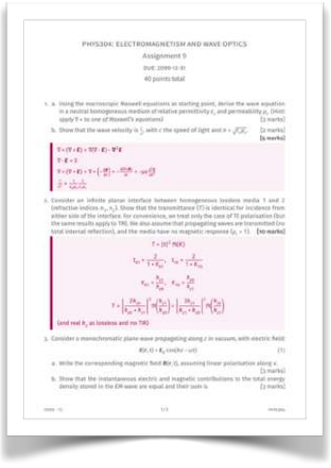
PART II: EXAMPLES

EXAM



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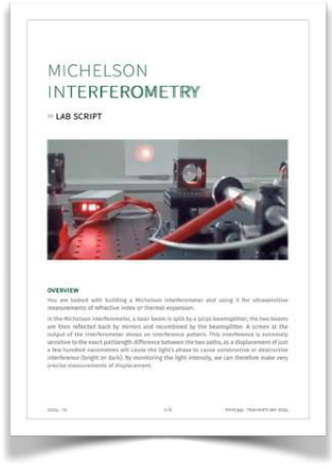

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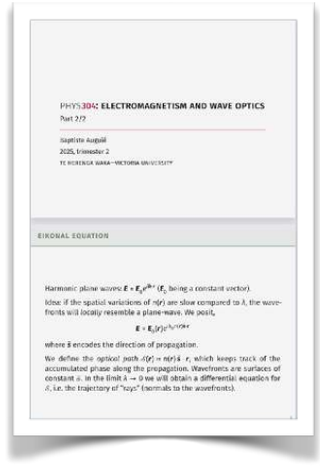


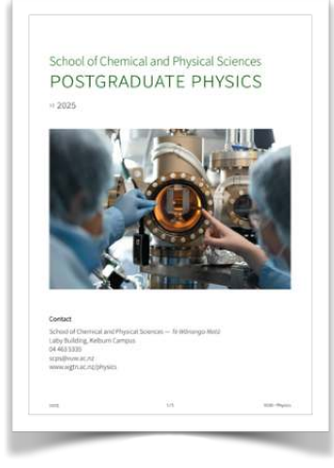
PRESENTATION

MARKING SHEET

COURSE INFO

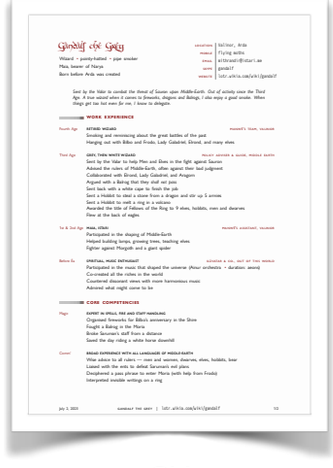
COURSE POSTER

PROGRAMME



BOOKLET

BANNER

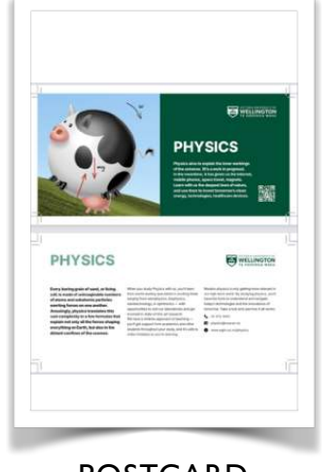


CV

RESEARCH POSTER

FLYER

BROCHURE



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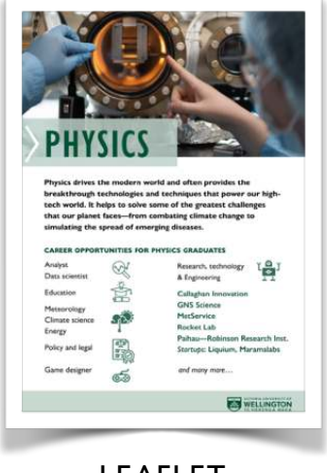

LEAFLET

AGENDA

CALENDAR

USING A TEMPLATE

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== Science of space

Orbital mechanics • rocketry •  physics of heat and energy •
the Sun •  solar weather

== Space for planet Earth

Remote sensing • monitoring climate change •  preserving
taonga species

== Space and society

Terraforming on Mars • extra-terrestrial life •  social and
political uses of orbiting technology
```

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SPCE101
INTRODUCTION TO SPACE SCIENCE

Overview of Space Science

- **Space and society**
  the place in space - the solar system -
  the universe - across the world - space in our lives -
  cultural aspects of space
- **Science of space**
  Orbital mechanics - natural and artificial satellites -
  thermodynamics for space - electromagnetism for space -
  light and its uses for space science
- **Get there in space**
  The dynamic Sun - solar cycle -
  introduction to space weather - Life in space

ENGR141
ENGINEERING SCIENCE

Concepts and role of science in modern engineering

- **Non-relativistic mechanics**
  laws of motion - work and energy - gravity
- **Thermodynamics**
  temperature - heat transfer - ideal gas -
  laws of thermodynamics
- **Waves**
  wave function - mechanical and sound waves -
  energy and power - interference
- **Mathematical concepts**
  elementary algebra - limits - derivatives - functions

ENGR142
ENGINEERING PHYSICS

Physics theory and practice relevant to electronics and computer systems engineering

- **Mechanics**
  Newtonian mechanics - free body diagrams -
  oscillators and rotational kinematics
- **Electricity**
  charge - current - resistance - voltage -
  capacitance - inductance - impedance -
  DC - AC circuits - phasors - filters

PHYS101
INTRODUCTION TO PHYSICS

Physical phenomena, problem-solving techniques and practical skills in mathematics

- **Non-relativistic mechanics**
  laws of motion - work and energy - gravity
- **Thermodynamics**
  temperature - heat transfer - ideal gas -
  laws of thermodynamics
- **Waves**
  wave function - mechanical and sound waves -
  energy and power - interference
- **Mathematical concepts**
  elementary algebra - limits - derivatives - functions

PHYS131
ENERGY & ENVIRONMENTAL PHYSICS

Basic physical concepts studied in the contexts of energy, Earth's resources and the environment

- **Concept of energy**
  what is energy? - energy and matter - role in everyday life -
  sustaining the demands of an energy-hungry society
- **Solar energy and the environment**
  solar radiation - interaction with Earth's atmosphere -
  effect on climate
- **Environmental hazards**
  noise - earthquakes and volcanoes - storms and floods -
  radiation hazards

SPCE102
INTRODUCTION TO THE UNIVERSE

An introduction to astronomy and astrophysics

- **Planets and orbits**
  the solar system - planet formation -
  interstellar medium - exoplanets
- **Physics of stars**
  the Sun as a star - stars in our galaxy -
  stellar evolution - black holes
- **Galaxies**
  The Milky Way - distant galaxies - active galactic nuclei
- **Elementary cosmology**
  The cosmic web - the expanding universe -
  dark matter - dark energy

PHYS142
CALCULUS-BASED PHYSICS

Physical laws of mechanics and electromagnetism using vectors and calculus

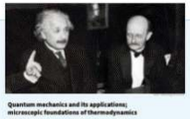
- **Mechanics**
  Vectors - vectors in 3 axes -
  damped forced oscillations - torque -
  angular momentum - rotational motion
- **Electricity & magnetism**
  Electrostatics - Coulomb's law - Gauss' Law -
  Magnetostatics - Biot-Savart's law - Ampère's law -
  Induction - Lenz' law - Faraday's law -
  applications to electrical circuits
- **Mathematical concepts**
  differential equations - integration -
  numerical solutions - vector algebra

PHYS145
PRACTICAL SKILLS FOR SCIENTISTS: APPLICATIONS IN PHYSICS

Introduction to numerical computing, data analysis, physics and mathematical skills for scientists

- **Develop and practice core scientific skills**
  units - functions - graphing - order-of-magnitude estimates -
  basic statistics - spreadsheet for data analysis -
  programming in Python - scientific reporting/writing
- **Hands-on exploration of physics concepts/experiments**
  quantum physics - fluid mechanics - optics - mechanics - circuits

PHYS241
QUANTUM MECHANICS & KINETIC THEORY



Quantum mechanics and its applications; microscopic foundations of thermodynamics

- **Quantum mechanics**
  wave-particle duality - superposition -
  Schrödinger's equation in 1D, 2D, 3D
- **Real applications of quantum physics**
  phenomena related to size quantisation, bound states,
  quantum confinement - quantum tunnelling & scattering -
  modern applications
- **Kinetic theory**
  deriving macroscopic properties of complex systems
  from the dynamics of its microscopic constituents

PHYS242
ELECTROMAGNETISM

Electromagnetic theory using vector calculus —applications to electrical circuits, electromagnetic waves

- **Vector calculus**
  Vector fields - operators ∇, ∇·, ∇×, - integration
- **Electrostatics**
  Gauss' law - electric potential
- **Magnetostatics**
  Biot-Savart & Ampère's laws - Lorentz force - vector potential
- **Electrodynamics**
  Faraday's law - Maxwell's equations
- **Electric circuits**
  DC - AC circuits - RLC circuits
- **Electromagnetic waves**
  plane waves - polarisation - interference - diffraction

PHYS243
CLASSICAL MECHANICS & RELATIVITY

An introduction to classical mechanics and Relativity

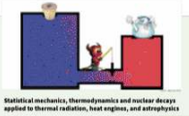
- **Lagrangian mechanics**
  generalised coordinates - Hamilton's principle -
  Lagrange's equations
- **Hamiltonian mechanics**
  the Hamiltonian - Hamilton's equations -
  Poisson brackets
- **Relativity**
  postulates of relativistic mechanics - implications:
  simultaneity, causality, time dilation, length contraction -
  4-dimensional space-time - introduction to General Relativity

PHYS245
METHODS OF EXPERIMENTAL PHYSICS

Acquisition, analysis, and presentation of experimental data

- **Instrumentation and experimental design**
  experimental setups - analysis and interpretation of data
- **Scientific computing**
  data acquisition - data manipulation and fitting -
  numerical models
- **Scientific communication of experimental results**
  documentation - oral and written presentation

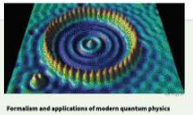
PHYS305
THERMAL & STATISTICAL PHYSICS



Statistical mechanics, thermodynamics and nuclear decays applied to thermal radiation, heat engines, and astrophysics

- **Statistical mechanics**
  Fermi-Dirac, Bose-Einstein, and classical distributions
- **Thermal physics**
  thermodynamics - heat propagation
- **Nuclear physics**
  nuclear decays - thermonuclear reactions
- **Applications**
  examples from thermal radiation, solid-state physics,
  astrophysics and chemical physics

PHYS307
QUANTUM MECHANICS



Formalism and applications of modern quantum physics

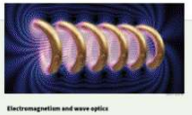
- **Introduction and overview**
  basic observations & phenomena - particle-wave duality -
  formal concepts - simple systems & their features -
  quantum technologies - scope & current state
- **Superposition & complementarity**
  formal concept of quantum state - observables as operators -
  measurements - compatibility, complementarity, uncertainty
- **Application to complex quantum systems**
  quantum oscillator as a paradigmatic system -
  quantum dynamics: Schrödinger's equation in 1D -
  angular momentum - time-independent perturbation theory

PHYS345
EXPERIMENTAL PHYSICS II

Advanced methods of experimental physics

- **Instrumentation and experimental design**
  data acquisition - experimental setups - automation
- **Scientific computing**
  data wrangling - numerical models -
  Bayesian data analysis - fitting
- **Scientific communication of experimental results**
  reporting - oral and written presentation - graphics
- **Applications & experimental skills**
  examples of modern laboratory & computational tools -
  optics - heat - vacuum - spectrometers - lab visits

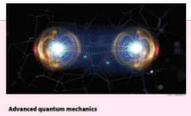
PHYS304
ELECTROMAGNETISM II



Electromagnetism and wave optics

- **Electrostatics and magnetostatics**
  Laplace's equation - multipoles -
  polarisation & magnetisation of matter
- **Time-varying fields**
  Faraday's law - Maxwell's equations
- **Electromagnetic waves**
  plane waves - Poynting vector - conservation laws -
  reflection & refraction at interfaces -
  multilayer optics - eikonal equation

PHYS411
QUANTUM MECHANICS



Advanced quantum mechanics

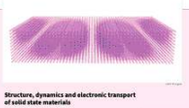
- **Principles of quantum mechanics**
  Hilbert spaces - Dirac notations -
  the postulates of quantum mechanics -
  interpretations
- **Advanced concepts**
  mixed states - density matrix -
  entanglement - Bell's inequalities -
  systems of identical particles
- **Relativistic quantum mechanics**

PHYS412
THEORETICAL PHYSICS

Theoretical tools and methods for many-body physics

- **Second quantization**
  identical particles - Fock space - thermal equilibrium
- **Green's functions in many-body physics**
- **Solution with diagrammatic theory**
  formalism for T = 0 - Feynman diagrams -
  extension to T > 0

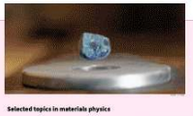
PHYS413
CONDENSED MATTER A



Structure, dynamics and electronic transport of solid state materials

- **Structure**
  crystal binding - crystal structure & X-ray diffraction
- **Dynamics**
  vibrational properties of crystals - phonons -
  thermal properties
- **Electronic structure**
  free-electron gas model - energy bands in crystals -
  charge & heat transport
- **Properties of low-dimensional / nano materials**
  confined semiconductor structures - topological insulators -
  graphene & carbon nanotubes

PHYS414
CONDENSED MATTER B



Selected topics in materials physics

- **Electrical conduction in metals and semiconductors**
- **Optical absorption/emission in semiconductors**
- **Ferroelectrics and piezoelectrics**
- **Superconductivity**
- **Electron-electron correlations**

PHYS415
ELECTROMAGNETISM

Topics in classical electrodynamics

- **Plasma physics**
  interactions of fields & charged particles -
  kinetic description of plasmas - magnetohydrodynamics -
  implications of field-particle dynamics for space physics
- **Maxwell's equations in media**
  microscopic vs macroscopic fields - conservation laws -
  anisotropic & nonlinear constitutive relations
- **Propagation of electromagnetic waves**
  absorption - dispersion - polarisation -
  guided waves - scattering

PHYS416
RELATIVITY & ELECTRODYNAMICS

Advanced concepts of special relativity and elements of field theory

- **Formal structure of special relativity**
  scalars, vectors, tensors in Minkowski space -
  Lorentz-invariant formulation of physical laws
- **Electromagnetism as a field theory**
  Lagrangian to fields - general Euler-Lagrange equations
- **Unconventional electromagnetism**
  massive photons - axion electrodynamics
- **Radiation of charges in ultra-relativistic motion**
  generalised Liénard-Wiechert potentials - synchrotron light

PHYS417
ASTROPHYSICS

Selection of topics in modern astrophysics

- **Radiative processes in the interstellar medium**
  radiative transfer - bremsstrahlung - synchrotron radiation
- **Structure formation in the Universe**
  gravitational collapse - galaxy formation - large-scale structure
- **Observational cosmology**
  the expanding Universe - dark matter and dark energy -
  the Cosmic Microwave Background

PHYS490|491
RESEARCH PROJECT

Introduction to physics research

Individual project in one of the research fields of the School. The projects may be experimental or theoretical in nature, or include elements of both.

Assessment consists 3 components:
- Research (30%) – effort, skills, dedication, initiative
- Written report (20%)
- Oral presentation (20%)

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PHYS304: ELECTROMAGNETISM AND WAVE OPTICS

Assignment 9

DUE: 2099-12-31

40 points total

1. a. Using the macroscopic Maxwell equations as starting point, derive the wave equation in a neutral homogeneous medium of relative permittivity ε_r and permeability μ_r. (*Hint: apply $\nabla\times$ to one of Maxwell's equations*) [3 marks]

   b. Show that the wave velocity is $\frac{c}{n}$, with c the speed of light and $n = \sqrt{\varepsilon_r \mu_r}$. [2 marks]

   [5 marks]

$$\nabla \times (\nabla \times \boldsymbol{E}) = \nabla(\nabla \cdot \boldsymbol{E}) - \nabla^2 \boldsymbol{E}$$

$$\nabla \cdot \boldsymbol{E} = 0$$

$$\nabla \times (\nabla \times \boldsymbol{E}) = \nabla \times \left(-\frac{\partial \boldsymbol{B}}{\partial t}\right) = -\frac{\partial(\nabla \times \boldsymbol{B})}{\partial t} = -\mu\varepsilon\frac{\partial^2 \boldsymbol{E}}{\partial t^2}$$

$$\frac{1}{v^2} = \frac{1}{\varepsilon_0 \mu_0}\frac{1}{\varepsilon_r \mu_r}$$

2. Consider an infinite planar interface between homogeneous lossless media 1 and 2 (refractive indices n_1, n_2). Show that the transmittance (T) is identical for incidence from either side of the interface. For convenience, we treat only the case of TE polarisation (but the same results apply to TM). We also assume that propagating waves are transmitted (no total internal reflection), and the media have no magnetic response ($\mu_r = 1$). **[10 marks]**

$$T = |t|^2 \, \Re(K)$$

$$t_{01} = \frac{2}{1 + K_{01}}, \quad t_{10} = \frac{2}{1 + K_{10}}$$

$$K_{01} = \frac{k_{z1}}{k_{z0}}, \quad K_{10} = \frac{k_{z0}}{k_{z1}}$$

$$T = \left|\frac{2k_{z0}}{k_{z0} + k_{z1}}\right|^2 \Re\left(\frac{k_{z1}}{k_{z0}}\right) = \left|\frac{2k_{z1}}{k_{z1} + k_{z0}}\right|^2 \Re\left(\frac{k_{z0}}{k_{z1}}\right)$$

(and real k_z as lossless and no TIR)

3. Consider a monochromatic plane wave propagating along z in vacuum, with electric field:

$$\boldsymbol{E}(\boldsymbol{r}, t) = \boldsymbol{E}_0 \cos(kz - \omega t) \tag{1}$$

   a. Write the corresponding magnetic field $\boldsymbol{B}(\boldsymbol{r}, t)$, assuming linear polarisation along x. [3 marks]

   b. Show that the instantaneous electric and magnetic contributions to the total energy density stored in the EM wave are equal and their sum is [3 marks]

2099 · T3 1/3 PHYS304

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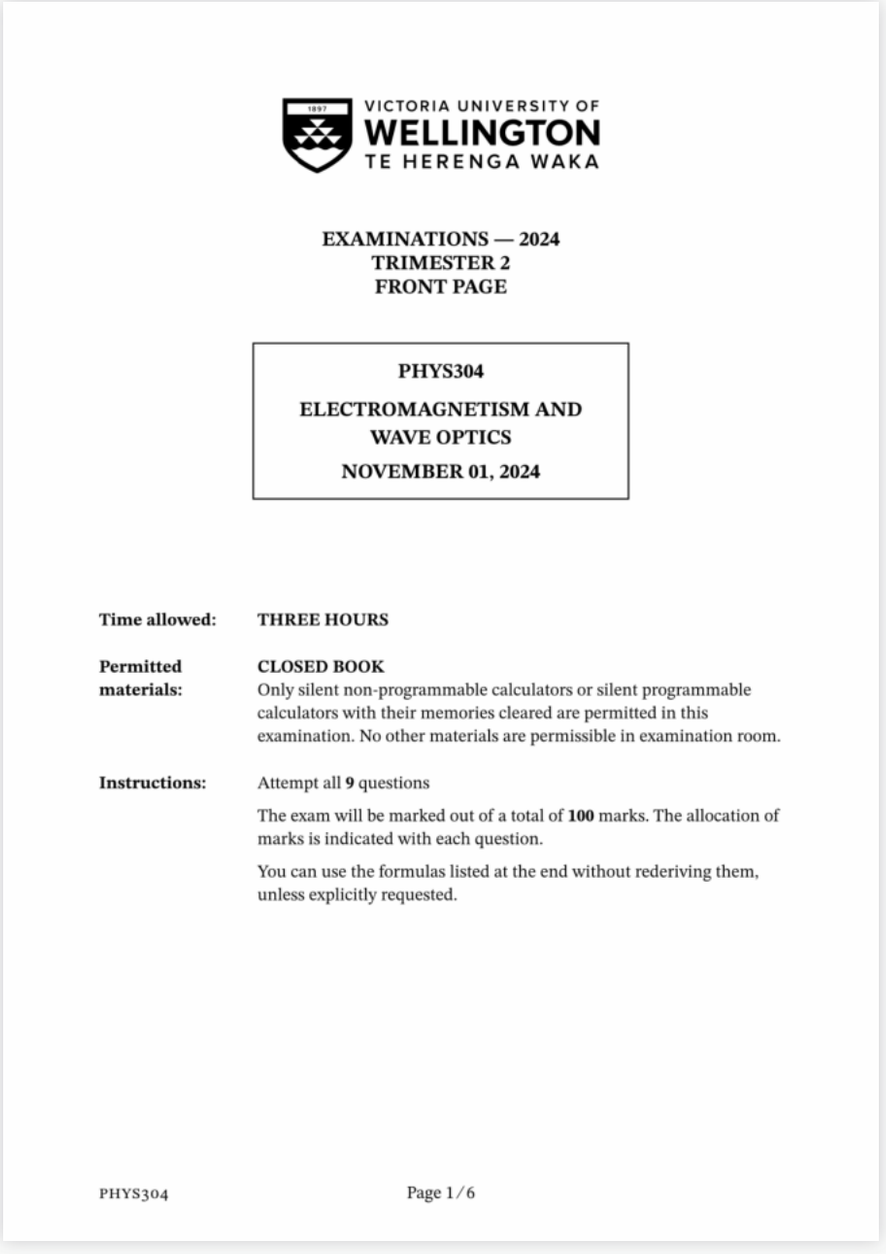

VICTORIA UNIVERSITY OF WELLINGTON
TE HERENGA WAKA

EXAMINATIONS — 2024
TRIMESTER 2
FRONT PAGE

PHYS304

ELECTROMAGNETISM AND WAVE OPTICS

NOVEMBER 01, 2024

Time allowed:	**THREE HOURS**
Permitted materials:	**CLOSED BOOK** Only silent non-programmable calculators or silent programmable calculators with their memories cleared are permitted in this examination. No other materials are permissible in examination room.
Instructions:	Attempt all **9** questions The exam will be marked out of a total of **100** marks. The allocation of marks is indicated with each question. You can use the formulas listed at the end without rederiving them, unless explicitly requested.

PHYS304 Page 1/6

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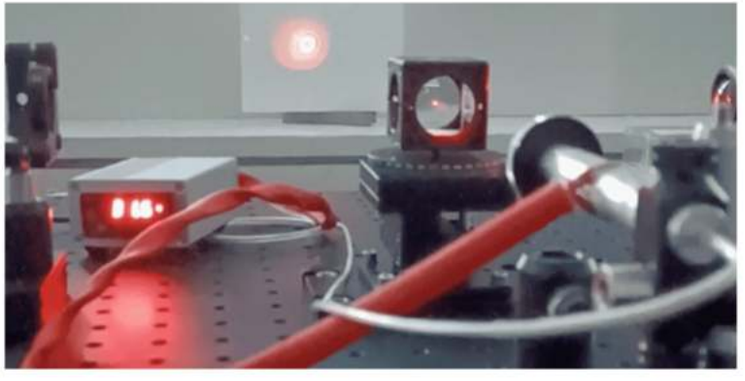
MICHELSON INTERFEROMETRY

›› LAB SCRIPT



OVERVIEW

You are tasked with building a Michelson interferometer and using it for ultrasensitive measurements of refractive index or thermal expansion.

In the Michelson interferometer, a laser beam is split by a 50:50 beamsplitter; the two beams are then reflected back by mirrors and recombined by the beamsplitter. A screen at the output of the interferometer shows an interference pattern. This interference is extremely sensitive to the exact pathlength difference between the two paths, as a displacement of just a few hundred nanometres will cause the light's phase to cause constructive or destructive interference (bright or dark). By monitoring the light intensity, we can therefore make very precise measurements of displacement.

2024 · T2 1/6 PHYS345 · TEACHER'S DAY 2024

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PHYS304: ELECTROMAGNETISM AND WAVE OPTICS

Part 2/2

Baptiste Auguié

2025, trimester 2

TE HERENGA WAKA—VICTORIA UNIVERSITY

EIKONAL EQUATION

Harmonic plane waves: $\boldsymbol{E} = \boldsymbol{E}_0 e^{i\boldsymbol{k}\cdot\boldsymbol{r}}$ ($\boldsymbol{E}_0$ being a constant vector).

Idea: if the spatial variations of $n(\boldsymbol{r})$ are slow compared to λ, the wavefronts will *locally* resemble a plane-wave. We posit,

$$\boldsymbol{E} = \boldsymbol{E}_0(\boldsymbol{r}) e^{ik_0 n(\boldsymbol{r})\hat{\boldsymbol{s}}\cdot\boldsymbol{r}}$$

where $\hat{\boldsymbol{s}}$ encodes the direction of propagation.

We define the *optical path* $\mathcal{S}(\boldsymbol{r}) \coloneqq n(\boldsymbol{r})\,\hat{\boldsymbol{s}}\cdot\boldsymbol{r}$, which keeps track of the accumulated phase along the propagation. Wavefronts are surfaces of constant $\mathcal{S}$. In the limit $\lambda \to 0$ we will obtain a differential equation for $\mathcal{S}$, i.e. the trajectory of "rays" (normals to the wavefronts).

1

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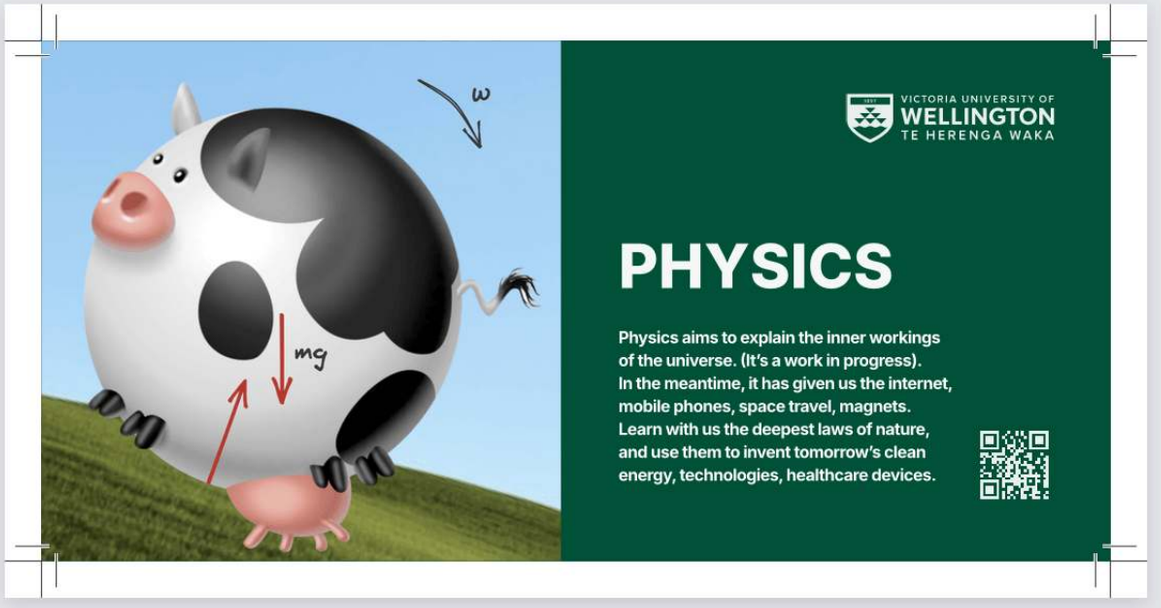

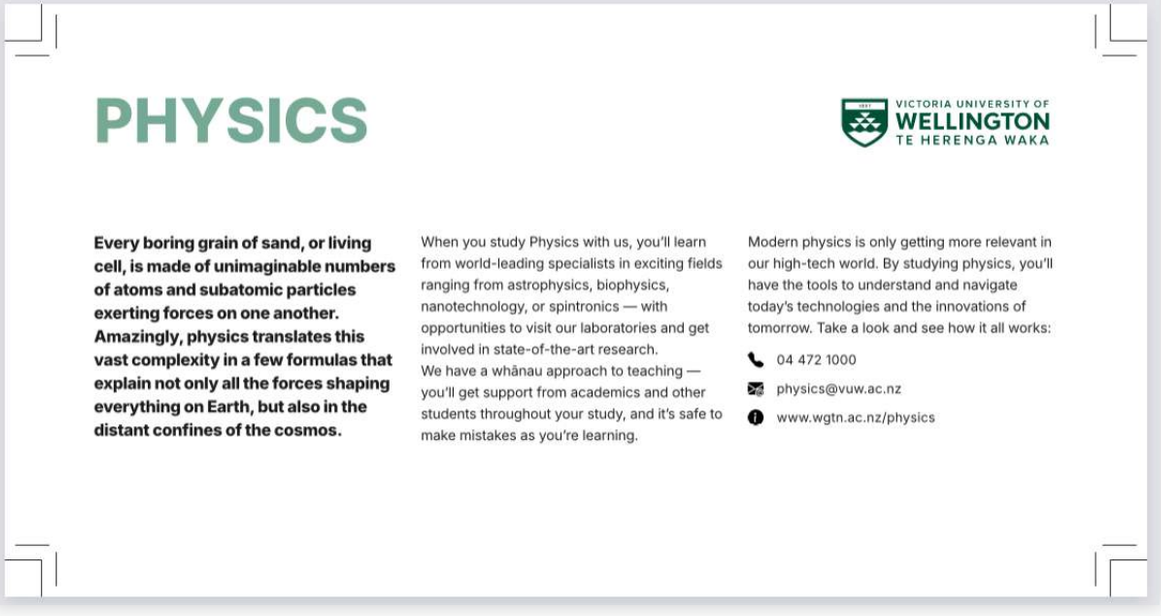

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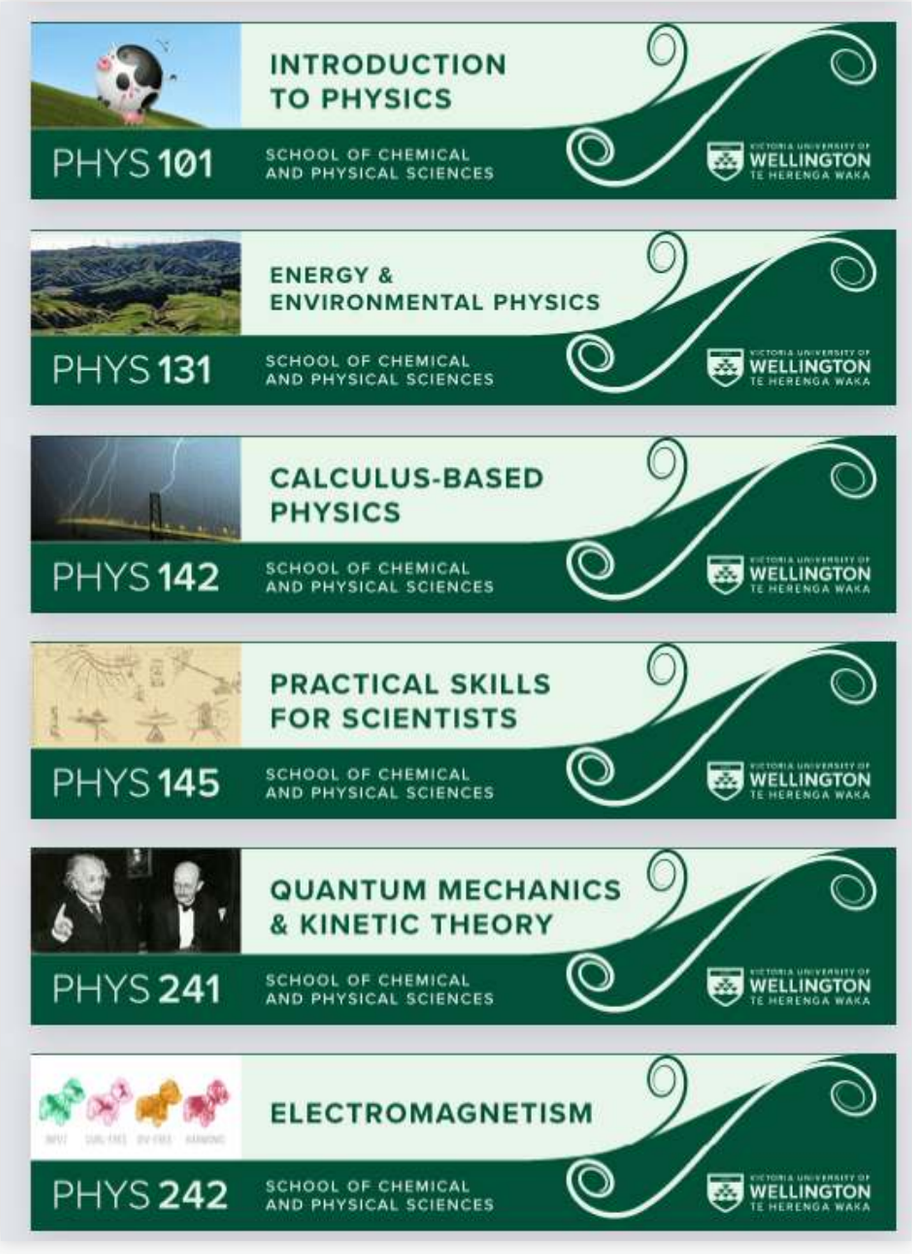
BANNERS



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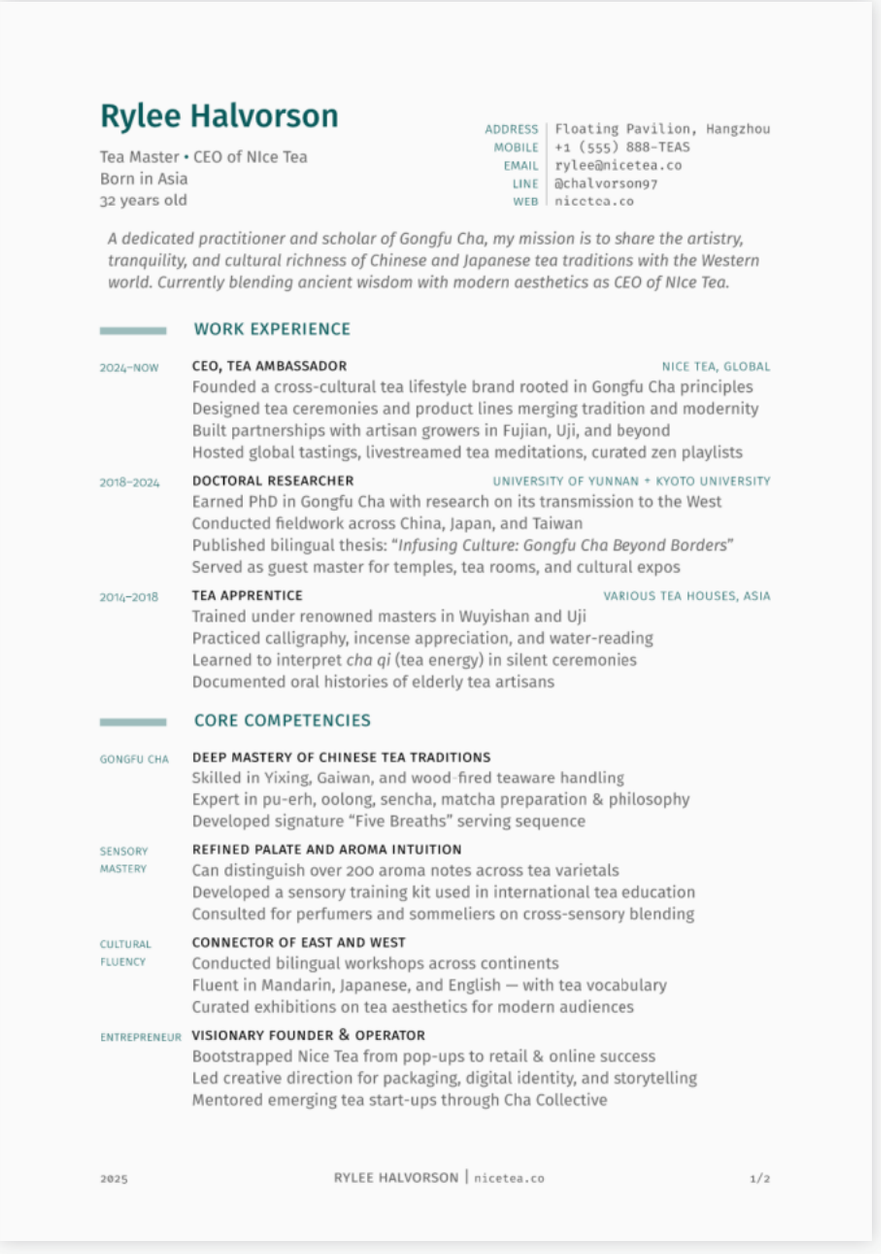

Rylee Halvorson

Tea Master • CEO of NIce Tea
Born in Asia
32 years old

ADDRESS | Floating Pavilion, Hangzhou
MOBILE | +1 (555) 888-TEAS
EMAIL | rylee@nicetea.co
LINE | @chalvorson97
WEB | nicetea.co

A dedicated practitioner and scholar of Gongfu Cha, my mission is to share the artistry, tranquility, and cultural richness of Chinese and Japanese tea traditions with the Western world. Currently blending ancient wisdom with modern aesthetics as CEO of NIce Tea.

WORK EXPERIENCE

2024–NOW — **CEO, TEA AMBASSADOR** — NICE TEA, GLOBAL
Founded a cross-cultural tea lifestyle brand rooted in Gongfu Cha principles
Designed tea ceremonies and product lines merging tradition and modernity
Built partnerships with artisan growers in Fujian, Uji, and beyond
Hosted global tastings, livestreamed tea meditations, curated zen playlists

2018–2024 — **DOCTORAL RESEARCHER** — UNIVERSITY OF YUNNAN + KYOTO UNIVERSITY
Earned PhD in Gongfu Cha with research on its transmission to the West
Conducted fieldwork across China, Japan, and Taiwan
Published bilingual thesis: "*Infusing Culture: Gongfu Cha Beyond Borders*"
Served as guest master for temples, tea rooms, and cultural expos

2014–2018 — **TEA APPRENTICE** — VARIOUS TEA HOUSES, ASIA
Trained under renowned masters in Wuyishan and Uji
Practiced calligraphy, incense appreciation, and water-reading
Learned to interpret *cha qi* (tea energy) in silent ceremonies
Documented oral histories of elderly tea artisans

CORE COMPETENCIES

GONGFU CHA — **DEEP MASTERY OF CHINESE TEA TRADITIONS**
Skilled in Yixing, Gaiwan, and wood-fired teaware handling
Expert in pu-erh, oolong, sencha, matcha preparation & philosophy
Developed signature "Five Breaths" serving sequence

SENSORY MASTERY — **REFINED PALATE AND AROMA INTUITION**
Can distinguish over 200 aroma notes across tea varietals
Developed a sensory training kit used in international tea education
Consulted for perfumers and sommeliers on cross-sensory blending

CULTURAL FLUENCY — **CONNECTOR OF EAST AND WEST**
Conducted bilingual workshops across continents
Fluent in Mandarin, Japanese, and English — with tea vocabulary
Curated exhibitions on tea aesthetics for modern audiences

ENTREPRENEUR — **VISIONARY FOUNDER & OPERATOR**
Bootstrapped Nice Tea from pop-ups to retail & online success
Led creative direction for packaging, digital identity, and storytelling
Mentored emerging tea start-ups through Cha Collective

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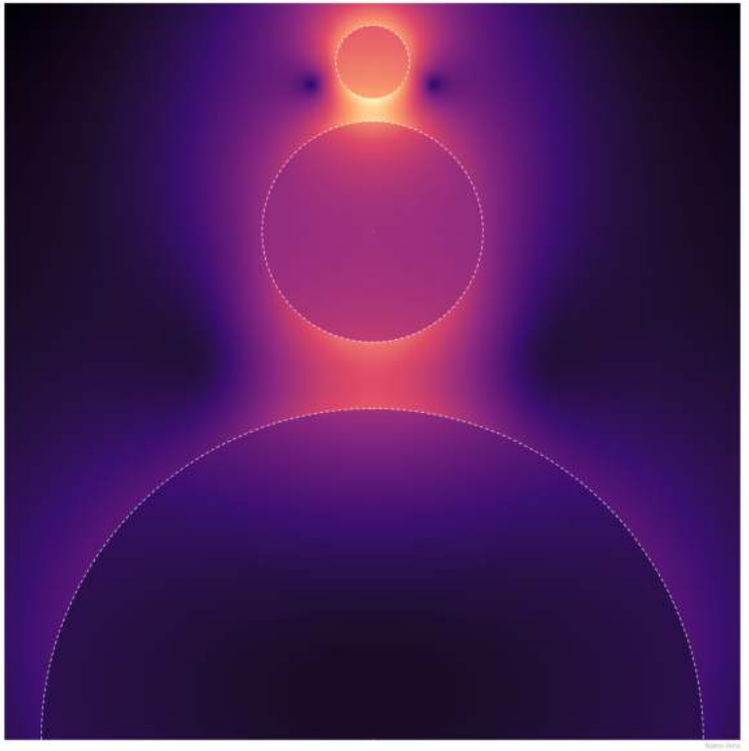
POSTER-SYNDROME



T · E · R · M · S

MULTIPLE SCATTERING OF LIGHT

Dmitri Scherbarchov
Atefeh Fazel-Najafabadi
Eric Le Ru
Baptiste Auguié

nano-optics.ac.nz/terms
2025-10-16

TERMS stands for T-matrix for Electromagnetic Radiation with Multiple Scatterers — it is a Fortran program to simulate the near-field and far-field optical properties of collections of particles. TERMS solves rigorously the Maxwell equations via the superposition T-matrix method, where incident and scattered fields are decomposed into a basis of multipolar electric and magnetic spherical waves.

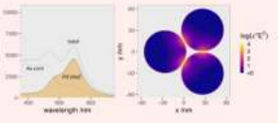
In a multiple-scattering problem the net field exciting a given particle is composed of the incident field plus the scattering contribution from neighbouring particles, resulting in a coupled system of equations to be solved for the total fields.

TERMS implements several algorithms to describe the self-consistent electromagnetic interaction between multiple scatterers, and from there compute optical properties such as absorption, scattering, extinction, circular dichroism, as well as near-field intensities and the local degree of optical chirality.

By describing the incident and scattered fields in a basis of spherical waves the T-matrix framework lends itself to analytical formulas for orientation-averaged quantities such as far-field cross-sections and near-field intensities, greatly reducing the computational time needed to simulate particles and systems of particles in random orientation.

EXAMPLE INPUT FILE

```
> ModeAndScheme 2 3
> MultipoleCutoff 15
> Wavelength 300 1000 300
> Medium 1.7689 # water
> Incidence 0.0 0.0 0.0 1
> # trimer of core-shell spheres
> Scatterers 3
> Au@Pd  0.0     0.0 0.0 30.0 29.0
> Au@Pd 52.481 30.3 0.0 30.0 29.0
> Au@Pd 52.481 30.3 0.0 30.0 29.0
```



Results from a simulation using the above input script

TERMS AND CONDITIONS

TERMS requires a Fortran 90 compiler; it processes input text files with specific keywords controlling the simulation parameters. Options include,

1. Far-field quantities (absorption, scattering, extinction, circular dichroism) for multiple wavelengths and angles of incidence, as well as orientation-averages
2. Near-field calculations for multiple wavelengths and incident angles, also computing the local degree of chirality, as well as orientation-averages
3. Stokes parameters and differential scattering cross-sections for multiple incidence or scattering angles

The computational cost scales with the size of the linear system, proportional to the number of particles N_p, and to the square of the maximum multipolar order N_{max}. On a typical PC we may treat up to ~ 500 particles with $N_{max} = 1$, and a dimer with N_{max} up to ~ 60.

THE T-MATRIX METHOD

Incident and scattered fields are expanded in a basis of Vector Spherical Waves (VSWs) $\boldsymbol{M}, \boldsymbol{M}$,

$$\boldsymbol{E}_{inc}(\boldsymbol{r}) = \sum_{p=1}^{2}\sum_{n=1}^{n_{max}}\sum_{m=-n}^{n} c_{mn}^{p}\boldsymbol{M}_{mn}^{p}(\boldsymbol{r})$$

$$\boldsymbol{E}_{sca}(\boldsymbol{r}) = \sum_{p=1}^{2}\sum_{n=1}^{n_{max}}\sum_{m=-n}^{n} c_{mn}^{p}\boldsymbol{M}_{mn}^{p}(\boldsymbol{r})$$

where n is the multipolar order, $|m| \le n$, and p is the parity (electric or magnetic type). Linearity of the Maxwell equations implies a linear relationship

$$\boldsymbol{c} = \boldsymbol{T}\boldsymbol{c}$$

defining the T-matrix for one scatterer. In practice, all quantities are truncated to a maximum multipolar order N_{max}.

MULTIPLE SCATTERING

Where multiple scatterers are present, the scattered field of one contributes to excite the others, leading to a coupled system of equations,

$$\boldsymbol{c}_{exc}^{(j)} = \boldsymbol{c}_{inc}^{(j)} + \sum_{\substack{i=1 \\ i\neq j}}^{N} \boldsymbol{O}^{(j,i)}\boldsymbol{T}_i^{(i)}\boldsymbol{c}_{exc}^{(i)}$$

to be solved self-consistently for the unknown excitation coefficients $\boldsymbol{c}_{exc}^{(j)}$, with numerical linear algebra routines.

The matrices $\boldsymbol{O}^{(j,i)}$ transform the VSWs expansion centred on one scatterer to another origin, and require special care to retain accuracy.
The T-matrix method finds limitations when the VSW series fails to converge in some regions near nonspherical particles, or when the circumscribed spheres of adjacent particles intersect.

OBTAINING T-MATRICES

The T-matrix for a given particle shape and composition can be obtained by a number of techniques, including general numerical solvers of Maxwell's equations. The extended boundary-condition method is arguably the most efficient and accurate; it connects the incident, scattered and internal fields at the particle boundary and provides the tmatrix elements as surface integrals of the VSWs. Simplifications occur for axi-symmetric particles such as spheroids, and for spheres in particular the tmatrix is simply diagonal, with analytical expressions for all elements in terms of spherical Bessel functions.

CALCULATION RESULTS

With knowledge of the scattered field coefficients one can compute the fields $\boldsymbol{E}, \boldsymbol{B}$ everywhere in space, as well as $|\boldsymbol{E}|^2$, $|\boldsymbol{E}|^4$, $\mathscr{C} \propto \Im(\boldsymbol{E}^* \cdot \boldsymbol{B})$, ...
Far-field cross-sections for extinction, scattering, absorption are obtained as

$$\sigma_{ext} = -\frac{1}{k_{med}^2}\Re\left\{\sum_{j=1}^{N}\boldsymbol{a}^{(j)\dagger}\boldsymbol{f}^{(j)}\right\}$$

$$\sigma_{sca} = \frac{1}{k_{med}^2}\Re\left\{\sum_{j=1}^{N}\sum_{i=1}^{N}\boldsymbol{f}^{(j)\dagger}tilde{\boldsymbol{O}}^{(j,i)}\boldsymbol{f}^{(i)}\right\}$$

$$\sigma_{abs} = \sigma_{ext} - \sigma_{sca}.$$

Orientation-averaged values such that

$$\langle X \rangle = \frac{1}{4\pi}\int_0^{\pi}\int_0^{2\pi} X(\varphi,\theta)\sin\theta d\varphi d\theta$$

for cross-sections $\langle\sigma_{ext}\rangle$, $\langle\sigma_{sca}\rangle$, $\langle\sigma_{abs}\rangle$ as well as near-field quantities $\langle|\boldsymbol{E}|^2\rangle$, $\langle\mathscr{C}\rangle$ can be obtained analytically in terms of the T-matrices and translation matrices.


CORE-SATELLITES


AU@PD TRIMER


AU NANOROD HELIX


RAYLEIGH HYPOTHESIS


AU NANOSTAR

NOTABLE FEATURES OF THE CODE

- Incident plane waves along arbitrary directions, with linear or circular polarisation
- Built-in calculation of individual for coated spheres; import of general from other programs
- Built-in dielectric functions for common materials such as Au, Ag, Al, Cr, Pt, Pd, Si, and Water, or from tabulated values
- Per-layer absorption in layered spheres
- Orientation-averaging of far-field cross-sections, as well as linear and circular dichroism
- Near-field maps of electric and magnetic field components, $|\boldsymbol{E}|^2$, $|\boldsymbol{E}|^4$, $\mathscr{C} \propto \Im(\boldsymbol{E}^* \cdot \boldsymbol{B})$
- Calculation of the global cluster
- "Masking" of specific multipolar orders
- Calculation of Stokes parameters, phase matrix, differential scattering
- Plain text or HDF5 I/O format
- Possible compilation in quad-precision

FUTURE DEVELOPMENTS

Additions only requiring additional code

- Built-in spheroidal particles
- Internal fields of spheroidal particles
- Orientation-averaged internal fields
- Dipolar emitter

Code optimisations or improvements

- Iterative solver, preconditioner
- Geometry optimisation (via external libraries)

Improvements to the theoretical framework

- Plane-wave expansion for particles with intersecting circumscribed spheres
- Conversion from / to cartesian polarisability tensors

We may also port the codebase to the Julia language for future development. Contact us if interested! (baptiste.auguie@vuw.ac.nz)

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T-matrix method and algorithms used in the code

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2. S. Lee, H Hwang et al, ACS Energy Lett, 3881–3890 (2020)
3. A. Fazel-Najafabadi, S. Schuster et al. Phys. Rev. B 103 (2020)
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7. D. Schebarchov, A. Fazel-Najafabadi et al. JQSRT 284 (2022)
8. L. Velasco, T. Ouyang, B.M. Reinhard Nano Lett. 23 (2023)
9. S. Glukhova, E.C. Le Ru, B. Auguié Nanoscale 15 (2023)
10. T. Ouyang, Y-C. Chen et al. ACS Nano 18 (2024)
11. [...] E.C. Le Ru, B. Auguié et al. JQSRT 333 (2025)

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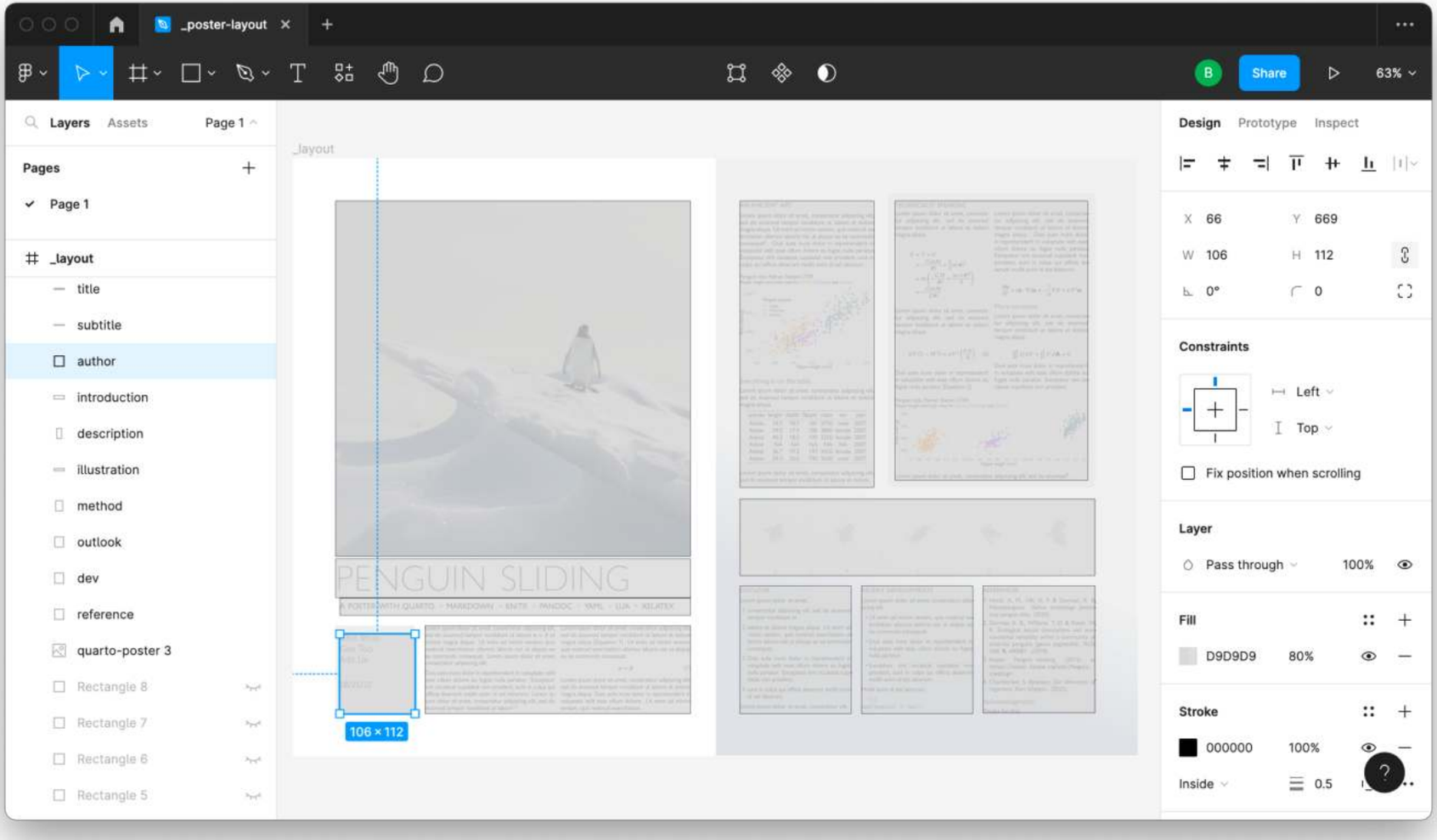
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PENGUIN SLIDING
106 × 112
Design
Prototype
Inspect
X 66
Y 669
W 106
H 112
0°
0
Constraints
Left
Top
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Pass through
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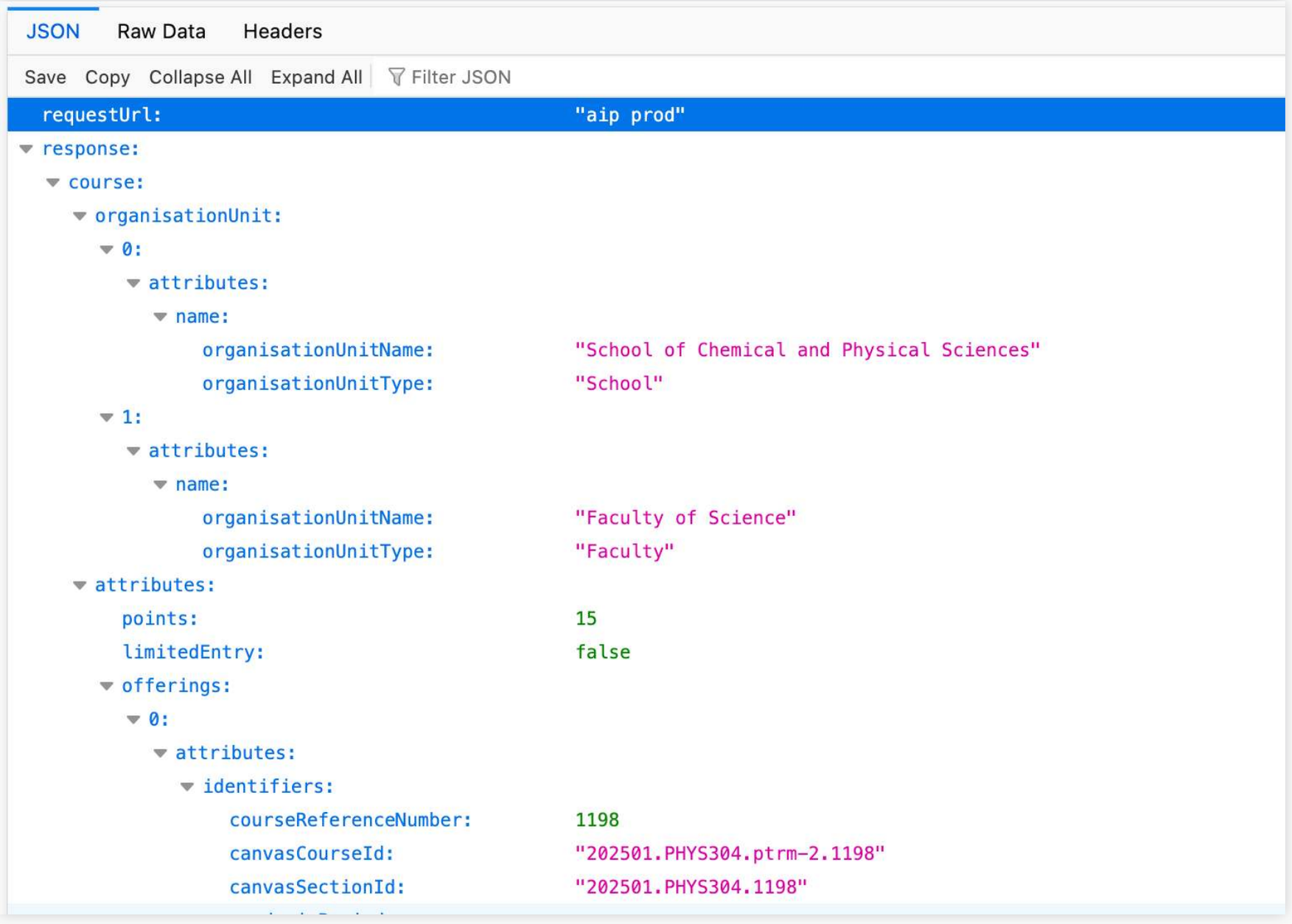
COURSE API



www.wgtn.ac.nz/api/sqc/courses/getCourseByCodeAndYear?course=phys304&year=2025

COURSE DATA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  "description": "This course will enable students that lack the full
prerequisites for CHEM 322 to do the reactivity and materials sections of
CHEM 322, in combination with a directed individual study component. The
course explores the structure and reactivity of molecules and materials. You
will learn about molecular structures, material structures, and their
properties and applications. The course discusses structure-property
relationships as a foundation towards molecular reactivities, and materials
applications in advanced technologies.     ",
  "points": "20",
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  "prerequisites": "CHEM 203;"
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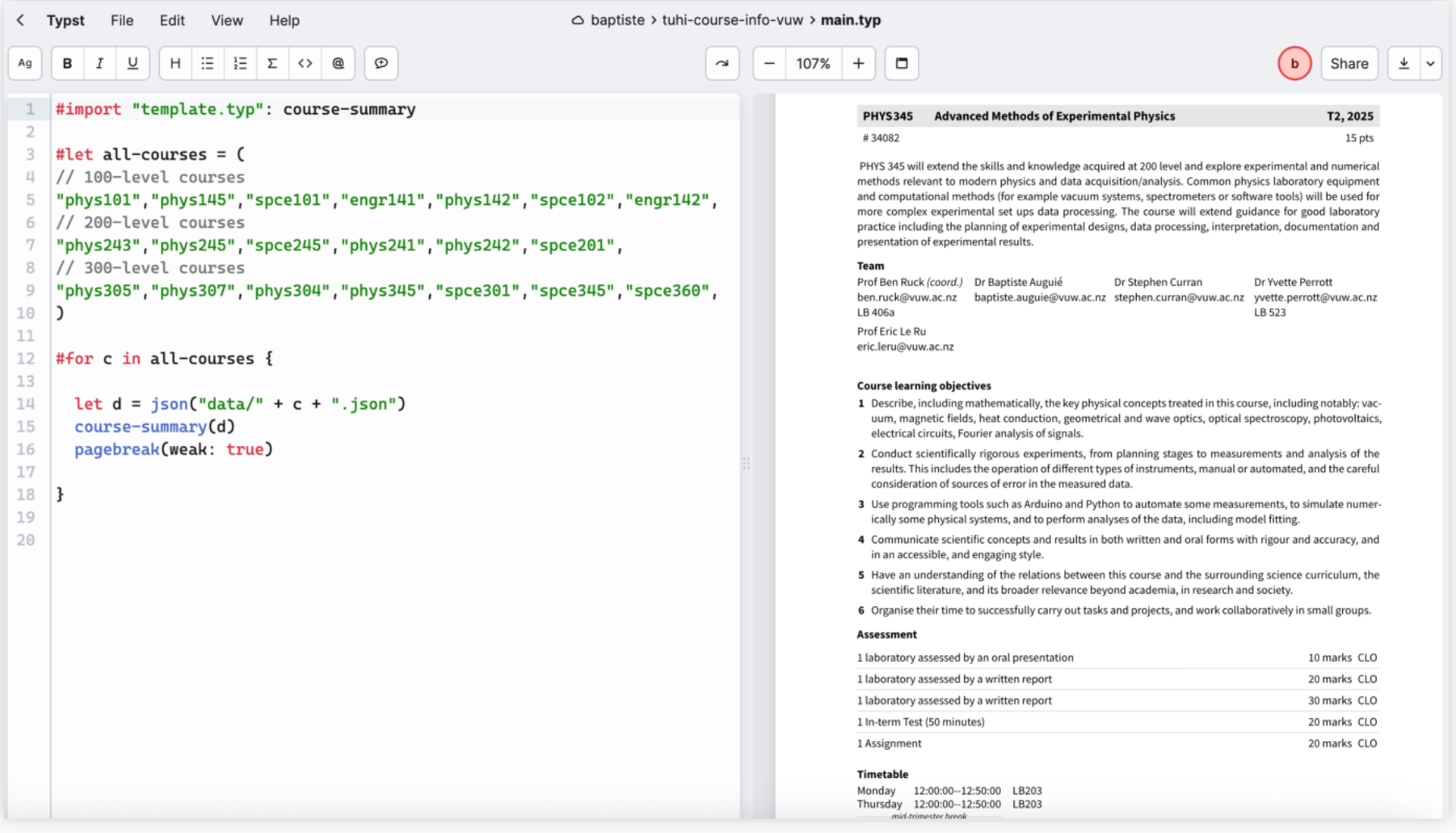
WHAT CAN WE DO WITH THESE DATA?



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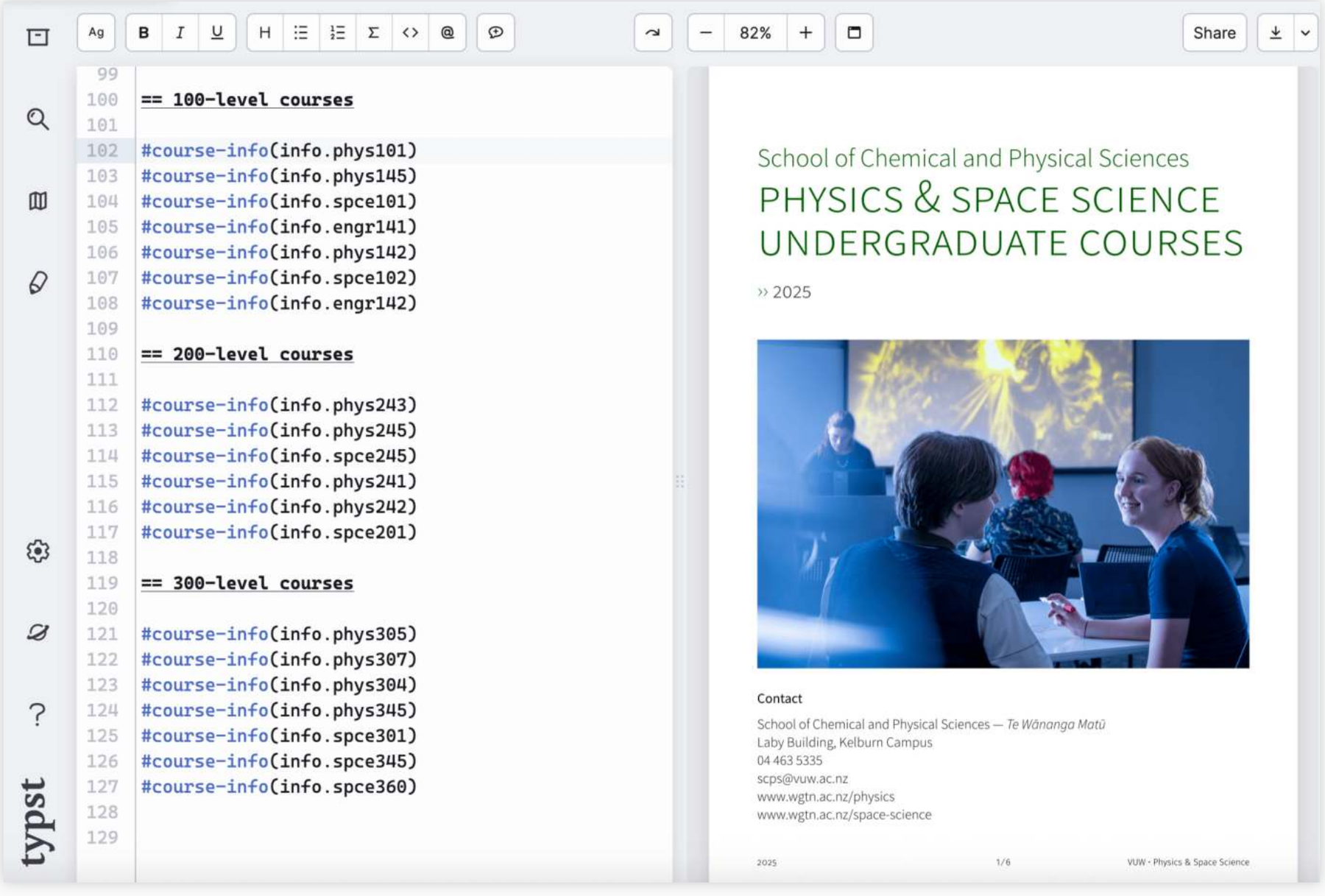

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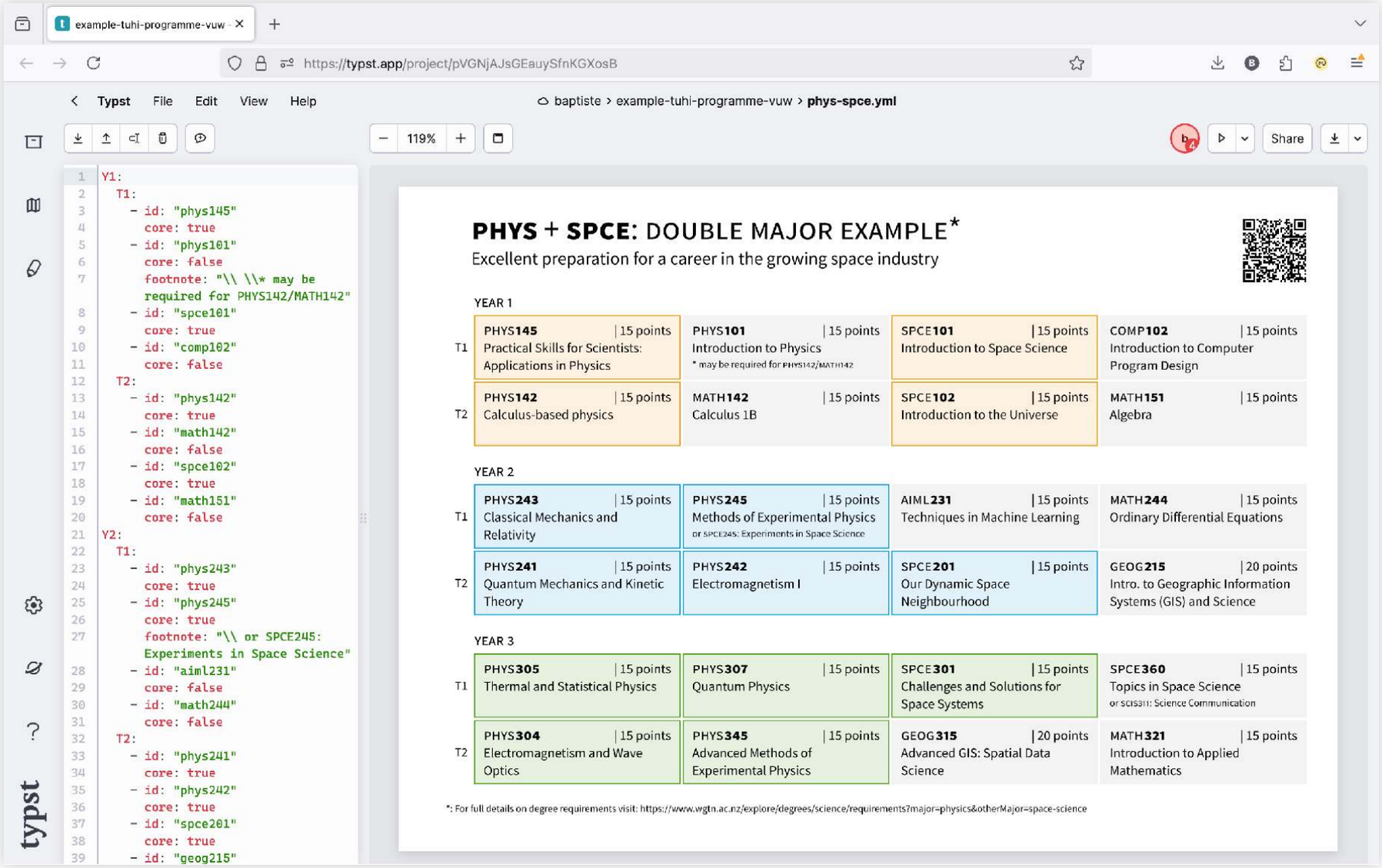

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YAML AGENDA

Agenda: Pumpkins and peanuts committee

DATE: 03/01/2000
TIME: 2 pm
LOCATION: baseball field

INVITED: Sally, Shroeder, Pig-pen, Marcie

	Topic	Preparation	Proposed process
1	**Misc. admin** TIME: 5 mins LEAD: baptiste PURPOSE: Inform, Admin	• Anything to change on the agenda? • Read minutes from last meeting • Review action points	• Check if agenda needs to be adjusted • Check if everyone's happy with the minutes • List top priorities of meeting and items needing decisions
2	**Snoopy's latest** TIME: 10 mins LEAD: Charlie Brown PURPOSE: Share, Discuss	• Bring your favorite comic strip • Reflect on Snoopy's recent escapades	• Discuss Snoopy's ongoing "battle" with the Red Baron • Share anecdotes of Snoopy's fiercest war moves • Plan a group outing to visit Snoopy's doghouse
3	**Woodstock's whereabouts** TIME: 5 mins LEAD: Linus PURPOSE: Locate, Update	• Bring binoculars for bird-watching • Brush up on bird calls	• Share any recent sightings or chirpings from Woodstock • Discuss strategies for bringing Woodstock back to the tunes • Plan an upside-down birdhouse-building workshop
4	**Prep for Great Pumpkin** TIME: 15 mins LEAD: Linus PURPOSE: Plan, Excite	• Bring your pumpkin-carving tools • Practice your most sincere pumpkin patch speech	• Discuss tactics for maximizing sincerity in the pumpkin patch • Brainstorm new ways to attract the Great Pumpkin's attention • Assign roles for the annual pumpkin carving contest
5	**Philosophical Musings** TIME: 20 mins LEAD: Lucy and Charles PURPOSE: Ponder, Reflect	• Bring your favorite existentialist quotes • Contemplate the meaning of life	• Engage in deep philosophical discussions under the night sky • Debate the nature of happiness, existence, and 5c psychiatry • Seek wisdom from Linus's trusty security blanket

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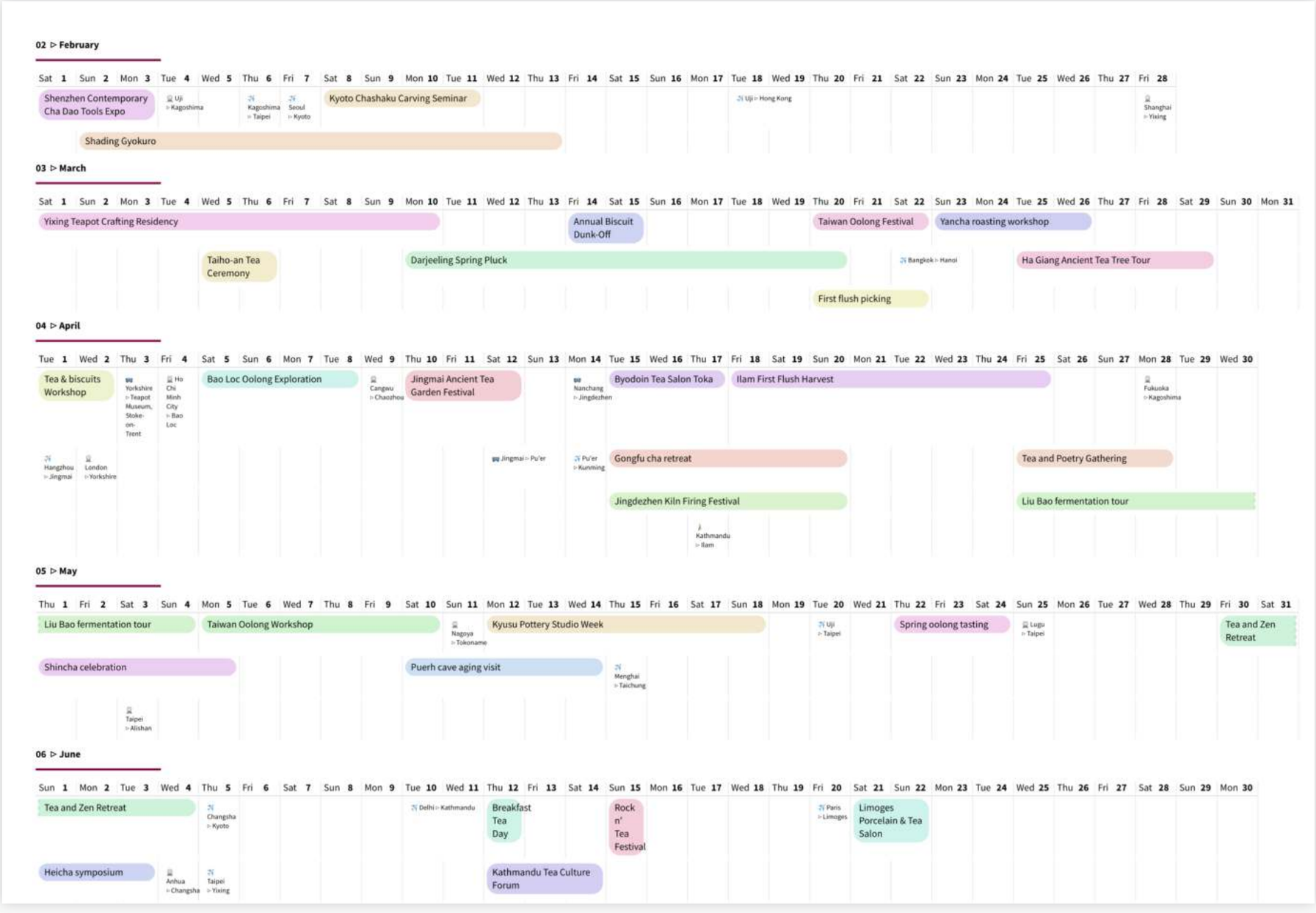
CALENDAR



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MARKING SHEET

2025-10-07	**ARI BELL**	[POLYMERS]	GRADE: **15** / 20	PHYS|SPCE345 (**CHEM**)

ORAL DELIVERY AND ANSWERS [4 / 5]

- timing kept, well distributed
- speak clearly, engage audience
- appropriate language
- accuracy
- pleasant and confident in manner of presenting and answering
- able to answer at the expected level

SLIDES [3.5 / 5]

- layout & presentation, proportion of words vs pictures
- structure: context, results, conclusions
- clear and legible graphics
- spelling and grammar
- references

CONTEXT [3 / 5]

- introduction to the topic, wider context
- motivation, aims of the project
- structure and methodology

CONTENT [4.5 / 5]

- clear description of procedures, methods and techniques

COMMENTS

- Integer fringilla, sem ac posuere
- amet viverra, magna nec feugiat
- consequat diam velit pretium

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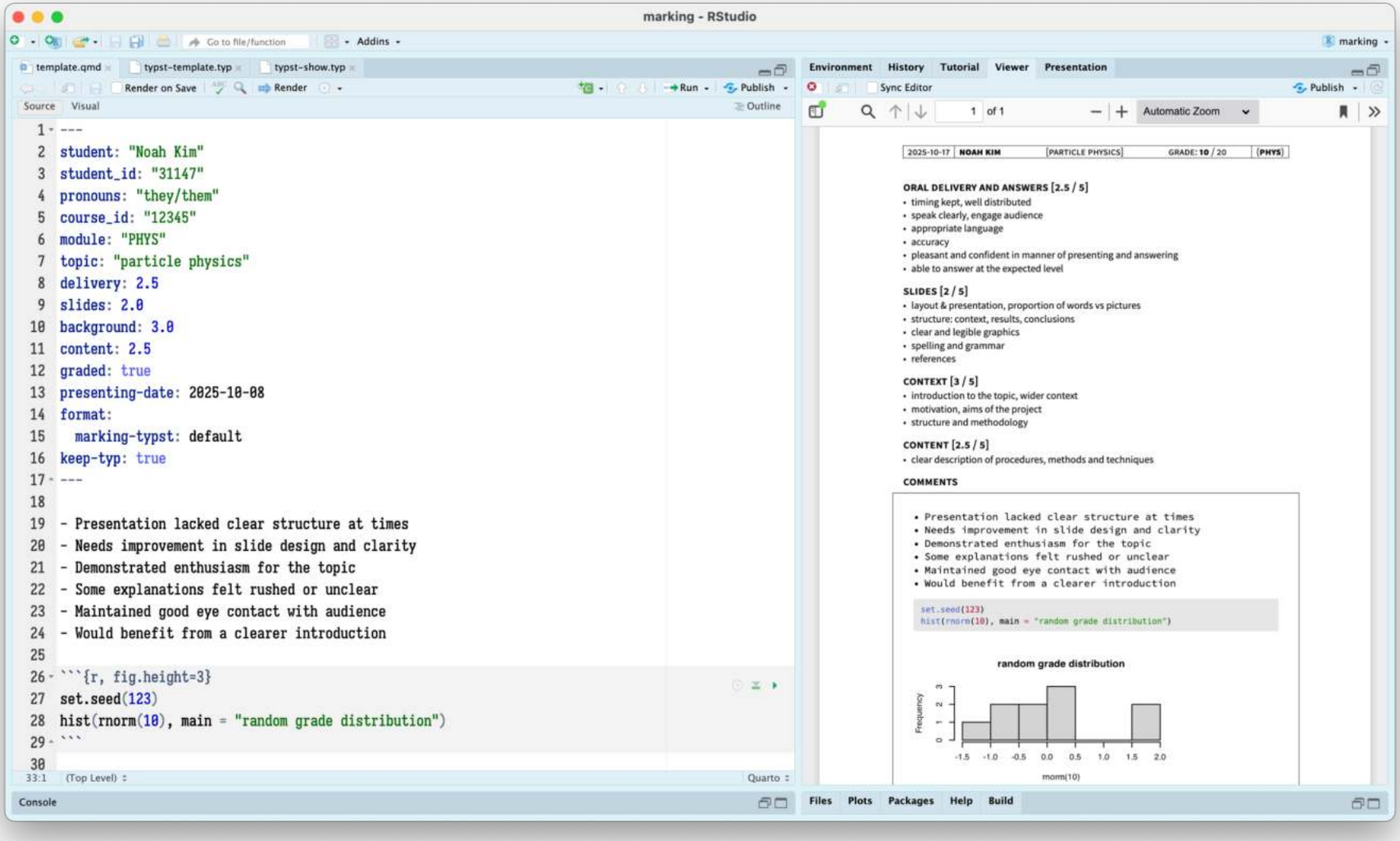
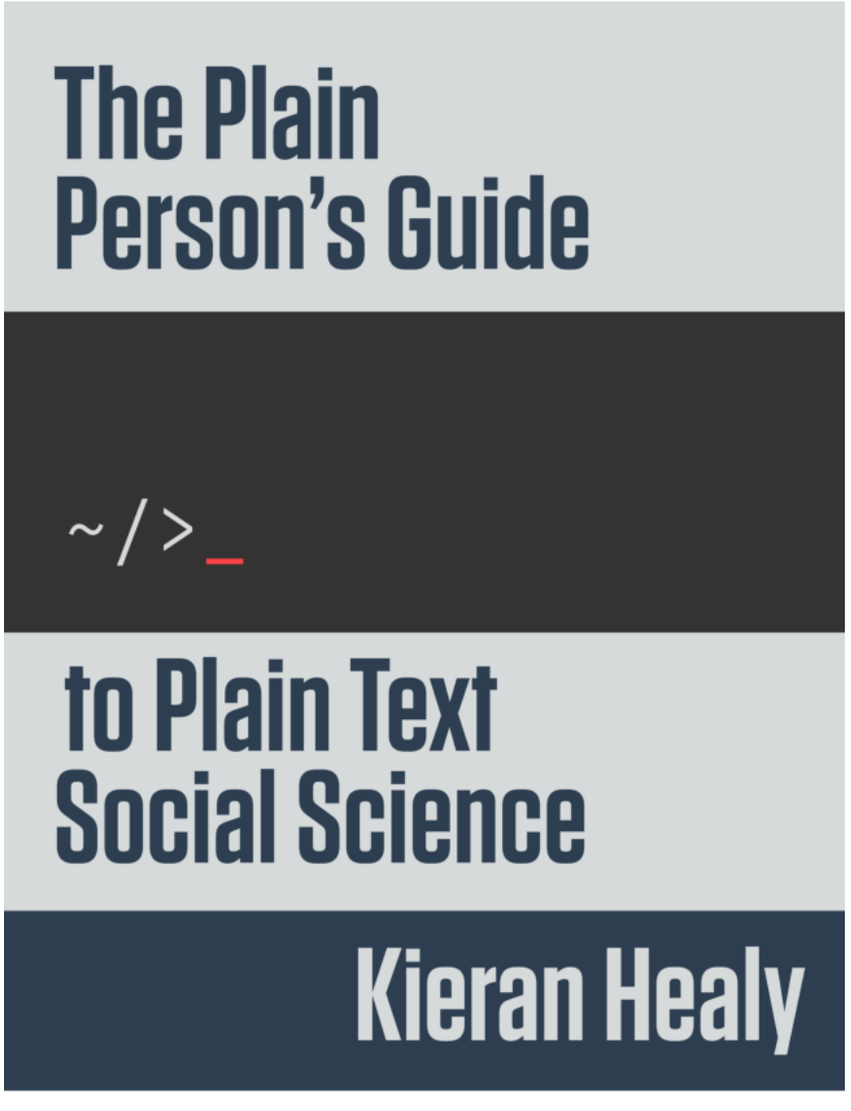
QUARTO → TYPST



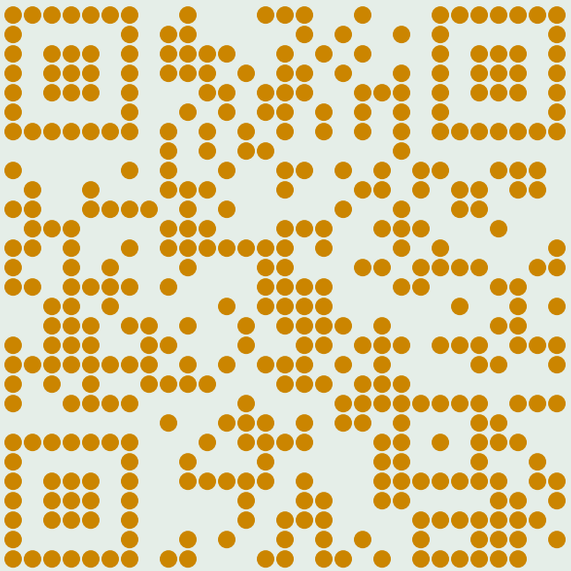
https://github.com/baptiste/quarto-marking-example

The problem is that doing scholarly work is intrinsically a mess. There's the annoying business of getting ideas and writing them down, of course, but also everything before, during, and around it: data analysis and all that comes with it, and the tedious but unavoidable machinery of scholarly papers—especially citations and references. There is a lot of keep track of, a lot to get right, and a lot to draw together at the time of writing.

— plain-text.co



PART III: PRACTICE



tinyurl.com/managed-typos

APPENDIX

FAQ

- **What is Typst?** — see typst.app/
- **Is it free?** — yes, and the compiler is open-source
- **Where do I find help?** — forum.typst.app/ or discord.gg/ek5hd7r6
- **I'm a Quarto user** — quarto.org/docs/output-formats/typst.html
- **I'm a LaTeX user** — typst.app/docs/guides/guide-for-latex-users/
- **My content is already in LaTeX/Markdown/Word** — pandoc.org/try/
- **Can I submit to journals?** — not really
- **Write a thesis?** — typst.app/universe/search/?category=thesis
- **MBIE CV?** — could be done
- **Does it produce PDF/UA?** — yes (v. 0.14) typst.app/docs/roadmap/
- **Why tuhi-...-vuw names?** — maoridictionary.co.nz/word/8645

- Plain text markup
- Advanced typography and layout control, similar to LaTeX
- Support for technical writing (equations, refs, figs., tables, ...)
- Built-in programming, e.g iterating over data to fill a table
- Tools available to convert to/from other formats
- Fast compilation, instant preview
- Modern editing environment, clear error reports
- Open source