School of Physics

# Course Outline 2021

# PHYS2113

# Classical Mechanics and Special Relativity

School of Physics

Faculty of Science

T2, 2021

# 1. Staff

| Position | Name | Email | Consultation times and locations | Contact Details |
|---|---|---|---|---|
| Course Convenor | Adam Micolich | adam.micolich@gmail.com | By arrangement via email | (02) 9385 6132 |
| Lecturer | Tim Duty | t.duty@unsw.edu.au | By arrangement via email | |
| Laboratory Manager | Tamara Reztsova | t.reztsova@unsw.edu.au | Higher Year Lab, Rm 142, Old Main Building | (02) 9385 4577 |
| Teaching Support Officer | Zofia Krawczyk-Bernotas | z.krawczyk-bernotas@unsw.edu.au | School of Physics office G06, Old Main Building | (02) 9385 5969 |

# 2. Course information

Units of credit: 6

Pre-requisite(s): (PHYS1221 or PHYS1231 or PHYS1241) and (MATH1231 or MATH1241)

Teaching times and locations: online

http://timetable.unsw.edu.au/2021/PHYS2113.html

## 2.1 Course summary

Classical mechanics is the study of the motion of objects obeying Newton's laws of motion, while Einstein's special theory of relativity revises the Galilean notion of relativity between inertial frames. This course aims to introduce students to the elegant Lagrangian and Hamiltonian formulations of Newtonian mechanics, and to the fundaments of special relativity and the associated 4-formalism. Students will receive a strong grounding in these methods, paving the way for advanced topics in electrodynamics, quantum mechanics and statistical mechanics.

Topics to be covered include:

- Lagrangian and Hamiltonian formulations of mechanics.
- Variational principles.
- Noether's theorem, symmetry, and conservation laws.
- Damped and forced harmonic oscillations and resonance phenomena.
- Coupled oscillators and normal modes.
- Foundations of special relativity.
- 4-formalism
- Lorentz transformation.
- Space-time diagrams.
- Relativistic kinematics and dynamics.
- Relativistic Doppler effect.

## 2.2 Course aims

**Graduate Attributes developed in this Course:**

- Research, inquiry, and analytical thinking abilities
- Capability and motivation for intellectual development
- Ethical, social, and professional understanding
- Communication in a scientific/technical context
- Collaborative and management skills
- Information literacy

## 2.3 Course learning outcomes (CLO)

By the end of this course you will:

- Solve problems in classical mechanics using the Lagrangian and Hamiltonian formulations.
- Explain the fundamental principles of special relativity and Lorentz transformation.
- Apply the 4-formalism of special relativity to analyse relativistic systems.
- Acquire and interpret experimental data.

## 2.4 Relationship between course and program learning outcomes and assessments.

Course Learning Outcomes 1-4 are assessed in the 3 assessment tasks. These assessments are largely of a critical-thinking nature designed to determine students' ability to deploy acquired knowledge to new situations, which is a key graduate attribute for successful physics-trained graduates.

# 3. Strategies and approaches to learning

## 3.1 Learning and teaching activities

**Assumed Knowledge**

Pre-requisite(s): (PHYS1221 or PHYS1231 or PHYS1241) and (MATH1231 or MATH1241)

**Timetable**

Lectures: 1 x 2hr, 2 x 1hr per week (Wk 1-5, 7-10) – See Moodle for details as the two lecturers will operate differently

Tutorials: 1hr per week (Wk 1-5, 7-10)

Laboratory: 3 x 3hr labs – The lab program for this course will be different to other higher year subjects (see below)

**Lecture Timetable (*Day Time Location*)**

Wednesday (wk 1-5, 7-10) 14:00-16:00 Online/Burrows Th

Friday (wk 1-5, 7-10) 12:00-14:00 Online/Mathews 103

**Lecture Information**

This course is taught by two lecturers teaching 16 hours each: See Moodle for more details on online vs face-to-face.

**Tutorial:** Friday (wk 1-5, 7-10) 10:00-11:00 Online/Mathews 103.

**Laboratory Information**

Students will complete a term-long lab project in 2021 with more complete details available on Moodle.

For details about lab days, times and class codes, see http://timetable.unsw.edu.au/2021/PHYS2113.html or contact Laboratory Staff (Tamara Reztsova at t.reztsova@unsw.edu.au).

## 3.2 Expectations of students

We believe that effective learning is best supported by a climate of enquiry, in which students are actively engaged in the learning process. To ensure effective learning, students should participate in class. Effective learning is achieved when students attend all classes, have prepared effectively for classes by reading through previous lecture notes or watching available video lecture content, in the case of lectures, and, in the case of tutorials or laboratories, have made a serious attempt at doing the problems or prework themselves prior to the class. Furthermore, lectures should be viewed by the student as an opportunity to learn, rather than just copy down lecture notes. Effective learning is achieved when students have a genuine interest in the subject and make a serious effort to master the basic material.

**Academic misconduct will not be tolerated in any form in this course**. Substantiated instances of cheating, plagiarism or copying answers may result in a failure grade or significant deduction of marks. Please https://student.unsw.edu.au/plagiarism if you are in any way unsure of what constitutes plagiarism. Assignments in this class are to be done independently.

# 4. Course schedule and structure

## Detailed Syllabus

*(section numbers refer to Classical Mechanics by JR Taylor)*
*Topics marked * are advanced topics that may be covered if time allows.*

**First half:** Calculus of Variations and the Euler-Lagrange equation (6.1, 6.2). Applications, more than two variables (6.3, 6.4). Lagrange's equations. Unconstrained motion, constrained motion (7.1, 7.2). Constrained systems in general (7.3, 7.4)**.** Examples. Generalised momenta and ignorable coordinates (7.5, 7.6). Conservation laws, Lagrange multipliers, Symmetry, Noether's theorem. (7.6, 7.8, 7.10). Hamilton mechanics in 1D systems, several dimensions (13.1, 13.2, 13.3). Canonical transformation, Lagrange vs. Hamilton (13.4, 13.5), Phase space orbits*, Liouville's theorem* (13.6, 13.7). Oscillations, Hooke's Law (5.1). Simple harmonic motion (5.2). 2D Oscillation (5.3). Damped and driven oscillations (5.4-5.5). Resonance (5.6).

**Second half:** Dynamics of vibrating systems, Normal modes, normal coordinates, coupled oscillators, loaded string (Chapter 11). Special relativity, Empirical background, Michelson-Morley, Postulate of SR, Time dilation, Length contraction (15.3, 15.4, 15.5), Lorentz transformation (15.6), Relativistic velocity addition, 4D space-time, 4–vectors (15.7, 15.8). Invariant scalar product, light cone, Doppler effect (15.9, 15.10, 15.11), Mass, 4-velocity, 4- momentum (15.12, 15.13), Forces in relativity, massless particles (15.15, 15.16), Tensors (15.17).

# 5. Assessment

## 5.1 Assessment tasks

**Assessment**
Course assessment comprises assignments, in-session test, laboratory and final examination.

| Assessment task | Length | Weight | Mark | Due date *(normally midnight on due date)* |
|---|---|---|---|---|
| Assignments/Quizzes | | 20% | | See Moodle (TBA). |
| Laboratory | | 20% | | See Moodle (TBA) |
| Final Exam | 2 hours | 60% | | See exam schedule (TBA) |

**Further information**

UNSW grading system: student.unsw.edu.au/grades

UNSW assessment policy: student.unsw.edu.au/assessment

## 5.2 Assessment criteria and standards

Please see Moodle for marking information for each assessment task

## 5.3 Submission of assessment tasks

**Assignment Submissions**
Unless otherwise specified, assignments should be submitted online by 5pm on the due date.

A downloadable assignment cover sheet is available from
https://www.physics.unsw.edu.au/current-students/cover-sheet

Marks will be deducted for late assignments, at a rate of 5% of the maximum possible mark for the assignment per day. A weekend will count as two days. An assignment submitted after the solutions have been posted will automatically receive 0%.

## 5.4. Feedback on assessment

Please see Moodle for details on how feedback will be provided for each assessment task

# 6. Academic integrity, referencing and plagiarism

**Referencing** is a way of acknowledging the sources of information that you use to research your assignments. You need to provide a reference whenever you draw on someone else's words, ideas or research. Not referencing other people's work can constitute plagiarism.

Further information about referencing styles can be located at student.unsw.edu.au/referencing

**Academic integrity** is fundamental to success at university. Academic integrity can be defined as a commitment to six fundamental values in academic pursuits**:** honesty, trust, fairness, respect, responsibility and courage.[1] At UNSW, this means that your work must be your own, and others' ideas should be appropriately acknowledged. If you don't follow these rules, plagiarism may be detected in your work.

Further information about academic integrity and **plagiarism** can be located at:

- The *Current Students* site student.unsw.edu.au/plagiarism**,** and
- The *ELISE* training site subjectguides.library.unsw.edu.au/elise

The *Conduct and Integrity Unit* provides further resources to assist you to understand your conduct obligations as a student: student.unsw.edu.au/conduct.

# 7. Readings and resources

*Prescribed:*
Classical Mechanics, John R. Taylor, University Science Books.

*Recommended:*
Introduction to Classical Mechanics, with Problems and Solutions. David Morin, Cambridge University Press.

**Other Resources**
The PHYS2113 lecture notes will be posted to Moodle.
Additional resources such as articles, papers, websites, other published material will be referred to during lectures and listed at the Moodle site.

**Course Aims and Learning Outcomes**

By the end of this course you will:

- Solve problems in classical mechanics using the Lagrangian and Hamiltonian formulations
- Explain the fundamental principles of special relativity and Lorentz transformation
- Apply the 4-formalism of special relativity to analyse relativistic systems
- Acquire and interpret experimental data

**Graduate Attributes Developed in this Course**

- Research, inquiry and analytical thinking abilities
- Capability and motivation for intellectual development
- Ethical, social and professional understanding
- Communication in a scientific/technical context
- Collaborative and management skills Information literacy

# 8. Administrative matters

**Communications**

[1] International Center for Academic Integrity, 'The Fundamental Values of Academic Integrity', T. Fishman (ed), Clemson University, 2013.

Students should check their UNSW email account regularly as all official university communication will be sent to that address. Students should use their university email account when writing to UNSW staff and should always include their name and student number.

**Health and Safety**

The School of Physics is actively committed to the health, safety and welfare of its staff and students. Information on relevant UNSW Occupational Health and Safety policies and expectations is available at: www.ohs.unsw.edu.au and https://www.physics.unsw.edu.au/about/safety

**Recommended Internet Sites**

The School of Physics website is www.physics.unsw.edu.au. Under the "Current Students" link students will find information about degrees, courses, and assessment.

The University website my.unsw.edu.au provides links to the UNSW Handbook, Timetables, Calendars and other student information.

**Student Complaint Procedures**

UNSW has procedures for dealing with complaints. These aim to solve grievances as quickly and as close to the source as possible. Information is available here: student.unsw.edu.au/complaints. Staff who can assist include:

**School Contacts:**

Zofia Krawczyk-Bernotas
Teaching Support Manager
School of Physics
Room G06, OMB
z.krawczyk-bernotas@unsw.edu.au
Tel: 9385 5969

Adam Micolich
Teaching Director
School of Physics
Room G57A, OMB
adam.micolich@unsw.edu.au
Tel: 9385 6132

Prof Susan Coppersmith
Head of School
School of Physics
s.coppersmtih@unsw.edu.au
Tel: 9385 4553

A/Prof Julian Berengut
Honours Coordinator
School of Physics
julian.berengut@unsw.edu.au
Tel: 9385 7637

# 9. Additional support for students

- The *Current Students* Gateway: student.unsw.edu.au
- Academic Skills and Support: student.unsw.edu.au/skills
- Student Wellbeing, Health and Safety: student.unsw.edu.au/wellbeing
- Disability Support Services: student.unsw.edu.au/disability
- UNSW IT Service Centre: www.it.unsw.edu.au/students