UNIVERSITY OF CALGARY
FACULTY OF SCIENCE
DEPARTMENT OF PHYSICS & ASTRONOMY
COURSE OUTLINE

1. **Course:** PHYS 609, Advanced Classical Mechanics -- Fall 2018

Instructor Name	Email	Phone	Office	Hours
L01: (TR 09:30 - 10:45 in SS 117)				
Sean Stotyn	sean.stotyn@ucalgary.ca	403-210-7594	Science A 101C	T 11:00–12:00

This one semester course in classical mechanics will emphasize modern approaches to a very old field. The Lagrangian formalism will be motivated right away with problems that are intractable using concepts of forces. Within the Lagrangian formalism, the importance of symmetries and their consequence of conservation laws will be shown. From the Lagrangian formalism, Legendre transformations will be used to develop the Hamiltonian formalism. Various powerful problem solving strategies will be explored; in particular, Hamilton-Jacobi theory and action-angle variables. The Lagrangian formalism of classical field theory (involving continuous variables as opposed to discrete particles) will be explored. Finally Noether's theorem will be derived, conclusively linking continuous symmetries to conserved quantities.

Course Site:

D2L: PHYS 609 L01-(Fall 2018)-Advanced Classical Mechanics

Department of Physics & Astronomy:
Office: Science B 605
Phone: 403 220-5385
Email: phasoffice@ucalgary.ca

Note:
Students must use their U of C account for all course correspondence.

2. **Requisites:**

See section 3.5.C in the Faculty of Science section of the online Calendar.

It is expected that a student's background will include Physics 343 or equivalent.

3. **Grading:**

The University policy on grading and related matters is described in F.1 and F.2 of the online University Calendar. In determining the overall grade in the course the following weights will be used:

Component(s)	Weighting %
In-class Worksheets	5
Assignments (5)	20
Term Project	25
Midterm Exams (x2, both take-home)	20
Final Exam (Registrar scheduled)	30

Each piece of work (reports, assignments, quizzes, midterm exam(s) or final examination) submitted by the student will be assigned a grade. The student's grade for each component listed above will be combined with the indicated weights to produce an overall percentage for the course, which will be used to determine the course letter grade.

The conversion between a percentage grade and letter grade is as follows.

	A+	A	A-	B+	B	B-	C+	C	C-	D+	D
Minimum % Required	95 %	90 %	85 %	80%	75%	70 %	66 %	63%	60%	57 %	55 %

There are two take-home midterm exams in this course. Both midterm exams will be open book, open resource, take-home exams given out in Tuesday lectures on Oct. 9 and Nov. 6, and are to be submitted at the beginning of the Thursday lectures on Oct. 11 and Nov. 8. The first midterm will cover Chapters 1 and 2 + relevant handouts. The second midterm will cover Chapters 8, 9, and parts of Chapter 10.

This course has a registrar scheduled final exam.

4. **Missed Components of Term Work:**

The regulations of the Faculty of Science pertaining to this matter are found in the Faculty of Science area of the Calendar in Section 3.6. It is the student's responsibility to familiarize himself/herself/themself with these regulations. See also Section E.3 of the University Calendar.

5. **Scheduled out-of-class activities:**

There are no scheduled out of class activities for this course.

6. **Course Materials:**

Required Textbook(s):

Goldstein, Poole, and Safko, *Classical Mechanics (3rd Ed)*: Addison Wesley .

A list of other recommended texts will be made available to the students on D2L.

Worksheets:

Periodically throughout the semester there will be worksheets to be completed in class and handed in at the end of lecture. The purpose of these worksheets is to increase student engagement and have you better construct the knowledge being learned in a structured manner. This is a formative assessment and will be treated as such; in particular, emphasis will not be on whether you have the correct answer, but rather the process you used to find it.

Expectations: It is essential that you work with fellow students during these in-class worksheets. It is expected that all steps be appropriately reasoned through so that somebody else can easily follow your thought process. All written work must be neat, organized, and legible.

Assignments:

There will be 5 homework assignments that will be due approximately every two weeks. Each assignment will be composed of a handful of challenging questions designed to expand the skills we develop in lecture. Solutions should be written on one side of a page, and multiple-page homework assignments must be stapled.

Expectations: It is encouraged that you work with fellow students on homework assignments in order to get a richer understanding of the material. However, the work you turn in must be yours and not a duplicate of someone else's. It is expected that all steps be appropriately reasoned through so that somebody else can easily follow your thought process. All written work must be neat, organized, and legible; any portions not following this will not be graded.

Term Project:

There are numerous topics that we will not get to cover in the course but are nevertheless interesting and important applications or extensions of the course material. To address these extra topics, students will get together in teams of 3 or 4 and deliver one full lecture on the chosen topic. There are multiple components to this project, which are expanded on below.

a) Lesson Plan Date: Nov. 1 Value: 3%

A good lecture is one that is well thought out and highly structured. Each group will be responsible for submitting a lesson plan for their upcoming lecture, with the opportunity to incorporate feedback from the instructor before finalizing their lecture. Details on what elements make a good lesson plan will be provided.

b) Notes to Post Due: Day of lecture Value: 4%

After their lecture, each group will provide a set of lecture notes (written, typed, PowerPoint, etc.) that will be posted

to D2L. These notes should be detailed enough so that a student missing class would know what was covered and how to catch up on the missed material.

c) Exam Style Question Due: Nov. 20 Value: 3%

In addition to designing and delivering a lecture on the chosen topic, each group will design and provide a full solution for a homework or exam style question on their chosen topic. The question should be at an appropriate level for the course and encapsulate one or more major idea presented in the lecture. Accompanying the question and solution should be a half page to maximum of one page typed philosophy statement outlining the purpose of the question, how it ties in with your chosen topic, what it aims to test, and how it aims to test it.

d) Interactive Lecture Dates: Nov. 27, 29 & Dec. 4, 6 Value: 10%

Each group will deliver a full 60-minute interactive lecture on their chosen topic, followed by 15 minutes of questions from the class. Each group member must have equal participation in the lecture, but not everyone in the group needs to do exactly the same things as each other. There are many ways to make a lecture interactive, and examples of some pedagogical techniques that you might like to use will be provided.

e) Peer & Self Evaluation Due: Dec. 11 Value: 5%

Evaluating a peer's work is important in technical fields, but even more important and useful is the ability to self-evaluate and self-reflect. Each student will be responsible for providing structured constructive feedback to the other groups on their lectures. Additionally, each lecture will be video recorded so that students can view their own lectures. As such, each student will be responsible for self-evaluating their own lecture.

Course Schedule:

The following is a rough outline of what topics we'll be covering, the reading that you'll be expected to do, about how long I expect to take on those topics, and important due dates. The asterisks signify a worksheet for that day's class.

Date	Sections	Topics covered	Due Dates
Sept. 6	N/A	Overview of course outline and syllabus, course incomes worksheet	
Sept. 11	1.3–1.4	Holonomic and nonholonomic constraints, equilibrium, principle of virtual work	
Sept. 13	1.4	D'Alembert's principle, dissipation, generalized force, Euler-Lagrange equations	
Sept. 18	N/A	Degrees of freedom, constraints, and generalized coordinates *	
Sept. 20	2.1–2.2	Hamilton's principle, calculus of variations, geodesic equations	Assignment 1
Sept. 25	2.2–2.3	Brachistochrone problem, Beltrami identity, techniques for solving problems	
Sept. 27	1.5, 2.5	Velocity-dependent potentials, Rayleigh dissipation function, coupled systems *	
Oct. 2	2.4	Constraints and Lagrange mutlipliers, semi-holonomic constraints	
Oct. 4	2.6, 2.7	Symmetries, conserved quantities, conservation of energy	Assignment 2
Oct. 9	8.1	Legendre transformations, conjugate momenta, Hamilton's equation of motion *	
Oct. 11	8.2, 8.3	Cyclic coordinates, conservation laws, Routh's procedure	Midterm 1
Oct. 16	8.5, 9.1	Hamilton's equations from variational principle, canonical transformations	
Oct. 18	9.1–9.3	Canonical transformations, the harmonic oscillator *	
Oct. 23	9.4–9.5	Poisson brackets, canonical invariants, equations of motion	
Oct. 25	9.5–9.6	Poisson brackets, infinitesimal canonical transformations, generators	Assignment 3
Oct. 30	10.1–10.3	Hamilton-Jacobi equation, example: the harmonic oscillator *	
Nov. 1	10.4, 10.5	Separation of variables, ignorable coordinates	Lesson Plan
Nov. 6	10.6, 10.7	Action-angle variables	
Nov. 8	13.1–13.2	Lagrangian formalism for continuous systems and fields *	Midterm 2
Nov. 20	13.3–13.4	Stress energy tensor, Hamiltonian formalism for continuous systems and fields	Exam Question
Nov. 22	13.7	Noether's theorem	Assignment 4
Nov. 27		TERM PROJECTS	
Nov. 29		TERM PROJECTS	
Dec. 4		TERM PROJECTS	
Dec. 6		TERM PROJECTS	Assignment 5

7. **Examination Policy:**

All examinations will be open book and open resource. Class notes, laptops, calculators, network-enabled devices, etc. are all permitted. Students can access any resource desired but are to work on the exams independently; communication between students during the examinations is NOT permitted. It is expected that all steps be appropriately reasoned through and explained so that somebody else can easily follow your thought process. All written work must be neat, organized, and legible; any portions not following this will not be graded.

Students should also read the Calendar, Section G, on Examinations.

8. **Approved Mandatory and Optional Course Supplemental Fees:**

   There are no mandatory or optional course supplemental fees for this course.

9. **Writing across the Curriculum Statement:**

   For all components of the course, in any written work, the quality of the student's writing (language, spelling, grammar, presentation etc.) can be a factor in the evaluation of the work. See also Section E.2 of the University Calendar.

10. **Human studies statement:**

    Students will not participate as subjects or researchers in human studies.

    See also Section E.5 of the University Calendar.

11. **Reappraisal of Grades:**

    A student wishing a reappraisal, should first attempt to review the graded work with the Course coordinator/instructor or department offering the course. Students with sufficient academic grounds may request a reappraisal. Non-academic grounds are not relevant for grade reappraisals. Students should be aware that the grade being reappraised may be raised, lowered or remain the same. See Section I.3 of the University Calendar.

    1. **Term Work:** The student should present their rationale as effectively and as fully as possible to the Course coordinator/instructor within **15 days** of either being notified about the mark, or of the item's return to the class. If the student is not satisfied with the outcome, the student shall immediately submit the Reappraisal of Graded Term work form to the department in which the course is offered. The department will arrange for a re-assessment of the work if, and only if, the student has sufficient academic grounds. See sections I.1 and I.2 of the University Calendar

    2. **Final Exam:** The student shall submit the request to Enrolment Services. See Section I.3 of the University Calendar.

12. **OTHER IMPORTANT INFORMATION FOR STUDENTS:**

    a. **Mental Health** The University of Calgary recognizes the pivotal role that student mental health plays in physical health, social connectedness and academic success, and aspires to create a caring and supportive campus community where individuals can freely talk about mental health and receive supports when needed. We encourage you to explore the mental health resources available throughout the university community, such as counselling, self-help resources, peer support or skills-building available through the SU Wellness Centre (Room 370, MacEwan Student Centre, Mental Health Services Website) and the Campus Mental Health Strategy website (Mental Health).

    b. **SU Wellness Center:** The Students Union Wellness Centre provides health and wellness support for students including information and counselling on physical health, mental health and nutrition. For more information, see www.ucalgary.ca/wellnesscentre or call 403-210-9355.

    c. **Sexual Violence:** The University of Calgary is committed to fostering a safe, productive learning environment. The Sexual Violence Policy (https://www.ucalgary.ca/policies/files/policies/sexual-violence-policy.pdf) is a fundamental element in creating and sustaining a safer campus environment for all community members. We understand that sexual violence can undermine students' academic success and we encourage students who have experienced some form of sexual misconduct to talk to someone about their experience, so they can get the support they need. The Sexual Violence Support Advocate, Carla Bertsch, can provide confidential support and information regarding sexual violence to all members of the university community. Carla can be reached by email (svsa@ucalgary.ca) or phone at 403-220-2208 .

    d. **Misconduct:** Academic misconduct (cheating, plagiarism, or any other form) is a very serious offence that will be dealt with rigorously in all cases. A single offence may lead to disciplinary probation or suspension or expulsion. The Faculty of Science follows a zero tolerance policy regarding dishonesty. Please read the sections of the University Calendar under Section K. Student Misconduct to inform yourself of definitions, processes and penalties. Examples of academic misconduct may include: submitting or presenting work as if it were the student's own work when it is not; submitting or presenting work in one course which has also been submitted in another course without the instructor's permission; collaborating in whole or in part without prior agreement of the instructor; borrowing experimental values from others without the instructor's approval; falsification/ fabrication of experimental values in a report. **These are only examples**.

    e. **Assembly Points:** In case of emergency during class time, be sure to FAMILIARIZE YOURSELF with the information on assembly points.

f. **Academic Accommodation Policy:** Students needing an accommodation because of a disability or medical condition should contact Student Accessibility Services in accordance with the procedure for accommodations for students with disabilities available at procedure-for-accommodations-for-students-with-disabilities.pdf.

   Students needing an accommodation in relation to their coursework or to fulfill requirements for a graduate degree, based on a protected ground other than disability, should communicate this need, preferably in writing, to the Associate Head of the Department of Physics & Astronomy, Dr. David Feder by email phas.ahugrd@ucalgary.ca or phone 403-220-8127. Religious accommodation requests relating to class, test or exam scheduling or absences must be submitted no later than **14 days** prior to the date in question. See Section E.4 of the University Calendar.

g. **Safewalk:** Campus Security will escort individuals day or night (See the Campus Safewalk website). Call 403-220-5333 for assistance. Use any campus phone, emergency phone or the yellow phones located at most parking lot pay booths.

h. **Freedom of Information and Privacy:** This course is conducted in accordance with the Freedom of Information and Protection of Privacy Act (FOIPP). Students should identify themselves on all written work by placing their name on the front page and their ID number on each subsequent page. For more information, see Legal Services website.

i. **Student Union Information:** VP Academic, Phone: 403-220-3911 Email: suvpaca@ucalgary.ca. SU Faculty Rep., Phone: 403-220-3913 Email: sciencerep@su.ucalgary.ca. Student Ombudsman, Email: suvpaca@ucalgary.ca.

j. **Internet and Electronic Device Information:** Unless instructed otherwise, cell phones should be turned off during class. All communication with other individuals via laptop, tablet, smart phone or other device is prohibited during class unless specifically permitted by the instructor. Students that violate this policy may be asked to leave the classroom. Repeated violations may result in a charge of misconduct.

k. **Surveys:** At the University of Calgary, feedback through the Universal Student Ratings of Instruction (USRI) survey and the Faculty of Science Teaching Feedback form provides valuable information to help with evaluating instruction, enhancing learning and teaching, and selecting courses. Your responses make a difference - please participate in these surveys.

Course Incomes:

Students entering the course should be able to:

- Analyze a physical system and identify all the constraints.
- State all of the kinetic and potential energies of a physical system.
- Apply the Euler-Lagrange equations to a Lagrangian to obtain the equations of motion.

Department Approval: Electronically Approved **Date:** 2018-09-05 14:57

Course Outcomes

- Construct Lagrangians for both time-independent (no dissipation) and time-dependent (driven and/or dissipative) systems.
- Identify symmetries and use Noether's theorem to find the corresponding conserved currents.
- Use Legendre transformations to construct a system's Hamiltonian from its Lagrangian, and vice versa.
- Apply canonical transformations and Hamilton-Jacobi theory to solve a variety of mechanical systems.
- Employ the Lagrangian and Hamiltonian formalisms for continuous systems and fields.