ACE Network Subject Information Guide

Lagrangian and Hamiltonian Dynamics, MATH4077

Semester 2, 2022

Administration and contact details

Host department	School of Mathematics and Statistics
Host institution	University of Sydney
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Subject details

Handbook entry URL	https://www.sydney.edu.au/units/MATH4077
Subject homepage URL	https://www.maths.usyd.edu.au/u/UG/HM/MATH4077/
Honours student hand-out URL	Click here to enter text.
Start date:	1 August
End date:	4 November
Contact hours per week:	3 lectures and 1 tutorial (13 weeks)
Census date:	31 August
Lecture day(s) and time(s):	Tue, Wed, Thu 12-1pm; recorded
Description of electronic access arrangements for students (for example, WebCT)	Access to websites and/or Ed to be arranged

Subject content

1. **Subject content description**

Lagrangian and Hamiltonian dynamics are a reformulation of classical Newtonian mechanics into a mathematically sophisticated framework that can be applied in many different coordinate systems. This formulation generalises elegantly to modern theories of relativity and quantum mechanics. The unit develops dynamics from the Principle of Least Action using the calculus of variations. Emphasis is placed on the relation between the symmetry and invariance properties of the Lagrangian and Hamiltonian functions and conservation laws. Coordinate and canonical transformations are introduced to make apparently complicated dynamical problems appear simpler. In this unit you will also explore connections between geometry and different physical theories beyond classical mechanics. You will be expected to solve fully dynamical systems of some complexity including planetary motion and to investigate stability using perturbation analysis. You will use Hamilton-Jacobi theory to solve problems ranging from geodesic motion (shortest path between two points) on curved surfaces to relativistic motion in the vicinity of black holes. This unit is a useful preparation for units in dynamical systems and chaos, and complements units in differential equations, quantum theory and general relativity.

2. Week-by-week topic overview

Week 01	Calculus of Variations
Week 02	Lagrangian Dynamics
Week 03	Central Forces
Week 04	Covariance of the Lagrangian Formalism
Week 05	Incorporating Constraints
Week 06	Hamiltonian Dynamics
Week 07	Geometric Connections
Week 08	Symmetry and Conservation Laws
Week 09	Hamilton-Jacobi Theory
Week 10	Completely Integrable Systems
Week 11	Applications (e.g. N-body problem, Relativity)
Week 12	Applications (e.g. Rigid body motion, Chaos)
Week 13	Revision

3. Assumed prerequisite knowledge and capabilities

Basic differential equations, solving constant coefficient inhomogeneous equations, separation of variables; fluent in integration techniques; basic linear algebra, solving systems, eigenvalues and eigenvectors; calculus of several variables; vector calculus, cylindrical and spherical coordinates

4. Learning outcomes and objectives

See https://www.sydney.edu.au/units/MATH4077/2020-S2C-ND-CC

AQF specific Program Learning Outcomes and Learning Outcome Descriptors (if available):

AQF Program Learning Outcomes addressed in this subject	Associated AQF Learning Outcome Descriptors for this subject
Insert Program Learning Outcome here	Choose from list below
Insert Program Learning Outcome here	Choose from list below
Insert Program Learning Outcome here	Choose from list below
Insert Program Learning Outcome here	Choose from list below
Insert Program Learning Outcome here	Choose from list below
Insert Program Learning Outcome here	Choose from list below
Insert Program Learning Outcome here	Choose from list below

Learning Outcome Descriptors at AQF Level 8

Knowledge

K1: coherent and advanced knowledge of the underlying principles and concepts in one or more disciplines

K2: knowledge of research principles and methods

Skills

S1: cognitive skills to review, analyse, consolidate and synthesise knowledge to identify and provide solutions to complex problem with intellectual independence

S2: cognitive and technical skills to demonstrate a broad understanding of a body of knowledge and theoretical concepts with advanced understanding in some areas

S3: cognitive skills to exercise critical thinking and judgement in developing new understanding

S4: technical skills to design and use in a research project

S5: communication skills to present clear and coherent exposition of knowledge and ideas to a variety of audiences

Application of Knowledge and Skills

A1: with initiative and judgement in professional practice and/or scholarship

A2: to adapt knowledge and skills in diverse contexts

A3: with responsibility and accountability for own learning and practice and in collaboration with others within broad parameters

A4: to plan and execute project work and/or a piece of research and scholarship with some independence

5. Learning resources

Lecture Notes “Lagrangian and Hamiltonian Dynamics” by Holger Dullin and Leon Poladian will be made available.

6. Assessment

Exam/assignment/classwork breakdown					
Exam	70 %	**Assignment**	10 %	**Class work**	2 Quizzes, 10%
Assignment due dates		Week 13, 6 Nov	.	Quiz 1, week 7, 13 Sep	Quiz 2, week 11, 18 Oct
Approximate exam date				Exams period 14 Nov – 27 Nov	

Institution honours program details

Weight of subject in total honours assessment at host department	One out of four coursework units
Thesis/subject split at host department	50% + 50%
Honours grade ranges at host department	
H1	80 - 100%
H2a	75 – 79%
H2b	70 – 74%
H3	65 – 69%

Institution masters program details

Weight of subject in total masters assessment at host department	One out of six coursework units
Thesis/subject split at host department	2/3 coursework + 1/3 thesis in 2nd year
Masters grade ranges at host department	
H1	80 - 100%
H2a	75 – 79%
H2b	70 – 74%
H3	65 – 69%