

P3151: Classical Mechanics (Fall 2011)

Department of Physics & Astronomy, University of Western Ontario, London PCD110810

Updated: 110914

A Hearty Invitation to P3151A 'CLASSICAL MECHANICS'

When: Weekly Monday, Wednesday, Friday: 10:30 am to 11:20 am.

Where: Classroom PAB-34

Classes begin on Friday, 9th September, 2011.

Assessment scheme:

Examination I (50 minutes test), on 14th Oct., Friday, during regular class → **15% weight**

Examination II (50 minutes test), on 14th Nov., Monday, during regular class → **15% weight**

End-Semester Examination (3 hours test), on 12th December (Monday) → **46% weight**

Assignments → 4 assignments, 6% weight per assignment → **24% weight**

Dear P3151 year student :

A very hearty welcome to this course on 'Classical Mechanics'! I shall offer it at UWO during the Fall-2011 semester. Earlier, I have been offering similar courses at the Indian Institute of Technology Madras (India). Besides, I also had an opportunity to offer related courses at IIT-Hyderabad and at IIT-Mandi.

This is amongst my most favorite courses! P3151 would begin, but only barely, with something that you already know, such as Newton's laws. Very quickly, we shall move into unexplored terrain, and find our way through an exciting path that would lay very strong foundations to learn advanced topics in physics. We shall first recognize the principle of conservation of momentum inbuilt in Newton's III law, and immediately proceed to reformulate this law as a consequence of translational invariance in homogeneous space. This alternative approach places the conclusions of Newton's III law on a completely different footing. The method we adopt in fact illustrates an exciting path of actually discovering laws of nature, using invariance/symmetry principles.

We shall then discuss a fascinating question: Are the conservation principles consequences of the laws of nature? Or, are the laws of nature consequences of the symmetry principles that govern them? Following the work of Albert Einstein, Emmy Noether and Eugene Wigner, we have learned that symmetry and invariance principles play an extremely fundamental role in contemporary physics. This approach is an important tool in the discovery of the laws of nature. We shall outline this approach using only elementary ideas that stem from Newtonian mechanics, and somewhat more lucidly from an 'alternative framework' of classical mechanics that is embodied in the 'principle of variation', developed in Lagrangian and Hamiltonian formulations. The central ideas in this discussion fall within the scope of the celebrated Noether's theorem, and even if only in a remote way, connect to the PCT/Lorentz invariance of the 'standard model' of physics, search for the Higgs boson in the LHC experiments etc. This approach hooks up elementary ideas in Physics to contemporary research in frontier areas, even if the intermediate links are challenging. Isn't that really wonderful? Mind you, even as we shall share the excitement of the Noether's theorem, our discussion will remain very much within your comfortable reach! Our discussion will be cast within the

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framework of familiar ground, by raising questions such as the following: other than energy and angular momentum, what else is conserved in the classical Kepler two-body problem?

In this course, we shall emphasize that 'observation' and 'measurements' play a fundamental role in Physics. You would have heard that the 'father' of experimental physics, Galileo, described mathematics as the very language of physics. We shall exploit rigorous mathematical methods as and where needed, but keep the focus on physical principles. The course will begin with a discussion on just 'what constitutes the mechanical state of a system', and how to pose and solve the problem of the 'evolution' of the mechanical system.

We shall also try to acquire reasonable introduction to understand real effects of pseudo forces, to field theory, to fluid dynamics and to the 'theory of chaos' ('chaos' itself needs no introduction, does it?). Time-permitting, we shall also introduce the special theory of relativity and discuss the intriguing 'twin paradox'.

The course will be (*un-*)covered in 6 (or 7) Units (appended below). To be able to break new ground in science and technology, scientists and engineers both would gain from a robust foundation in Physics. It shall be our endeavor to provide just that. **The course will be dense; you are advised to work very hard, absolutely from day 1.** We shall together rediscover the romance in physics, beauty in its simplicity, and rigor in its formulation.

- P. C. Deshmukh
August 10th, 2011

P3151: Classical Mechanics (~13 weeks, 3 credits course: ~39 classes)

Classes begin on Friday, 9th September. The last class will be on Wednesday, 7th December.

This course is structured in 7 units. Each unit will take us about 5 to 7 classes over approximately two weeks.

- Unit 1: Conservation principles and the laws of nature.** 'Dynamical symmetry' in the Kepler Problem connected with the constancy/conservation of the Laplace-Runge-Lenz vector.
- Unit 2: Principle of Variation.** Alternative formulation of Mechanics via 'Principle of Variation'. Lagrangian and Hamiltonian formulation. Application to SHO. Determination of conservation laws from symmetry. Poisson brackets, canonical transformations.
- Unit 3: Inertial and non-inertial reference frames.** Real effects of pseudo-forces. Using 'Pseudo force' to simulate Newton's formulation in accelerated frames of reference.
- Unit 4: Introduction to Field Theory.** Physical examples of fields. Potential energy function. Gradient, Directional Derivative, Divergence of a vector field. Gauss' Law; Equation of Continuity. Hydrodynamic and Electrodynamical illustrations.
- Unit 5: Introduction to Fluid Dynamics.** Fluid Flow, Bernoulli's Principle. Equation of motion for fluid flow. Velocity Curl, Vorticity, Irrotational flow and circulation. Steady State flow.
- Unit 6: Introduction to the theory of Chaos:** Complex behavior of simple systems. Introduction to 'fractals', 'attractors', 'self-similarity', 'Hausdorff/fractional dimensions', and to the beauty and complexity of Mandelbrot sets.
- Unit 7 (If time permits!): Introduction to 'Special Theory of Relativity'.** Connection between Special Theory of Relativity and Laws of Electrodynamics. 'Twin' Paradox.

- P. C. Deshmukh

WSC-G4; Ph:(519) 661-2111 ext. 86058, pdeshmu@uwo.ca / Wednesday, the 10th August, 2011

Instructor: P.C.Deshmukh

Updated: 14th Sept. 2011

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Contact: Office: WSC G4
Phone : (519) 661-2111 ext. 86058
Email: pdeshmu@uwo.ca

References: You will gain from "Classical mechanics of particles and systems" 5th Edn. by Thornton and Marion. Also, 'Berkeley Physics Course', Volume I, Feynman Lectures Volume I & II are good sources, both instructive and entertaining. Besides, we shall refer you to some other texts and articles – I shall provide these references from time to time during the course. No single book will be completely adequate; please do not miss classes!

Lecture time-table/venue: Mondays, Wednesdays, Fridays: 10:30am to 11:20am / in PAB 34.

Office Hours: Tuesdays, 3:30 to 5pm and Thursdays, from 1:00pm to 3:30pm, or any other time by appointment. Also, you are welcome to drop by whenever my office door is open. I will be glad to talk to you unless preoccupied with something that cannot wait!

Tests and exams: There will be two midterm examinations (15% each), a final exam (46%). You will get 24% credit for working out the solutions to four assignments (6% each). You are encouraged to work in small groups on the assignments. Not everybody may solve each problem on her/his own, but each of you is expected to submit the solution on proper understanding of the solution. I shall trust your conscience for this, and will have a chance to test it in the three exams. Each midterm or exam will generally test all the (integrated) material taught up to that point. No electronic equipment of any kind (eg. calculators, computers, cell phones, etc) will be allowed during any of the exams.

Assignments: Some of the problems given in the assignments may be chosen as material for exams. **PENALTY on late submission: 10% of your score on that particular assignment up to a maximum of 72 hours after deadline. Assignments will not be accepted beyond this delay.**

Course Policies

Stringent eligibility test will need to be satisfied to qualify for a make-up exam in case you miss any of the two mid-term examinations, or the end-semester final exam.

- **Missed midterm examinations/final exam:** Documentation must be provided to the instructor in order for you to receive permission to write a make-up. This process should be begun by your bringing the documentation to your student counseling office. If you miss the make-up, again documentation must be provided, and your mark will be pro-rated.
- **Missed final exam** Documentation must be provided to the academic counselors in your faculty in order for you to receive permission to write a make-up, usually scheduled for the day after the end of the exam period (plan your travel accordingly!). If you miss the make-up, again documentation must be provided, and you will then write the exam at the next sitting of this course's final exam (typically one year later).
- **Illness or other serious circumstances:** If you are unable to meet a course requirement due to illness or other serious circumstances, you must provide valid medical or other supporting documentation to the Dean's office as soon as possible and contact your instructor immediately. It is the student's responsibility to make alternative arrangements with their instructor once the accommodation has been approved and the instructor has been informed. In the event of a missed final exam, a "Recommendation of Special Examination" form must be obtained from the Dean's Office immediately. For further information please see [the medical section](#) of the Academic Handbook.

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A student requiring academic accommodation due to illness should use the Student Medical Certificate when visiting an off-campus medical facility or request a Record's Release Form (located in the Dean's Office) for visits to Student Health Services. The form can be found [here](#).

- **Religious holidays** A student who, due to unavoidable conflicts with religious holidays which (a) require an absence from the University or (b) prohibit or require certain activities (i.e., activities that would make it impossible for the student to satisfy the academic requirements scheduled on the day(s) involved), is unable to write examinations and term tests on a Sabbath or Holy Day in a particular term shall give notice of this fact in writing to his or her Dean as early as possible but not later than November 15th for mid-year examinations and March 1st for final examinations, i.e., approximately two weeks after the posting of the mid-year and final examination schedule respectively. In the case of mid-term tests, such notification is to be given in writing to the instructor within 48 hours of the announcement of the date of the mid-term test. The instructor(s) in the case of mid-term tests and the dean in the case of mid-year and spring final examinations will arrange for special examination(s) to be written at another time. In the case of mid-year and spring final examinations, the accommodation must occur no later than one month after the end of the examination period involved. It is mandatory that students seeking accommodations under this policy give notification before the deadlines, and that the Faculty accommodate these requests. The list of approved dates is given in the [UWO calendar](#).

- The final course marks may need to be adjusted in consultation with the academic administration in order to conform to departmental policy.

- **Prerequisites** Unless you have either the requisites for this course or written special permission from your Dean to enroll in it, you may be removed from this course and it will be deleted from your record. This decision may not be appealed. You will receive no adjustment to your fees in the event that you are dropped from a course for failing to have the necessary prerequisites.

Academic misconduct

- **Cheating** University policy states that cheating is a scholastic offence which can result in an academic penalty (which may include expulsion from the program). If you are caught cheating, there will be no second warning. Cheating includes having available any electronic devices other than a watch. You may not have a cell phone accessible during tests or exams, even to use it as a watch. Complete information on the University policies on academic offenses can be found in the Undergraduate section of [this document](#).

- **Plagiarism** Students must write their essays and assignments in their own words. Whenever students take an idea or a passage from another author, they must acknowledge their debt both by using quotation marks where appropriate and by proper referencing (such as footnotes or citations). Plagiarism is a major academic offence. For more details, see [this document](#).

- **Accessibility Statement** Please contact the course instructor if you require material in an alternate format or if you require any other arrangements to make this course more accessible to you. You may also wish to contact Services for Students with Disabilities (SSD) at 661-2111 x 82147 for any specific question regarding an accommodation.

- **Other Advice for successful performance** Some class notes will be uploaded on the course webpage, but do not necessarily include everything which might be tested. Some explanations given in class might not appear in the class notes, but are testable material. To do well in this course, you must do the weekly readings. Some of the midterm and exam questions will come from some of the references I shall be citing, but will not have been addressed in class.

- P. C. Deshmukh

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