Intermediate Classical Mechanics

Prereq: One of PHYS 263, AMATH 261, 271; One of MATH 227, 237, 247; MATH 228 or AMATH 250

2012F Session

Instructor
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Learning Objectives
This course is largely concerned with the study of analytical mechanics – Lagrangian and Hamiltonian formalisms. These formalisms allow for the solution of a broader class of problems than the Newtonian formalism. At the conclusion of this course the student should be comfortable in the manipulation of Lagrange’s and Hamilton’s Equations and their physical interpretation and solutions.

The study of small oscillations and normal modes should provide insight into, and mathematical tools for, subsequent courses on both quantum and statistical mechanics.

The study of non-inertial frames of reference provides further insight into the importance of an appropriate choice of coordinate systems.

On a higher level, this course is about symmetry and the conservation laws of physics.

Textbook

Assignments

Course Content

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Assignments

There will be weekly assignments. Only a selection of the submitted problems will be marked. Late assignments will be docked 20% per day; however, due dates can be extended if there is class consensus and the request is made sufficiently beforehand.

The purpose of the assignments is not evaluation but, rather, to help you understand the material and to prepare you for the tests and exam. You should make use of the resources available (the textbook, the library & internet, your peers and your instructor – in that order) so that you can complete the assignments correctly and on-time. The assignments must, of course, be your own work.

Assignments will be administered through the learn.uwaterloo.ca web site.

Term Test
There will be two 90 minute term tests which are tentatively scheduled for Oct 4th and Nov 8th.

Exam
There will be a 150 minute exam to be scheduled by the registrar.
Assessment
Assignments 10%
Readings 5%
Essay 5%
Term Test 2 x 15%
Exam 50%

Important Dates
Sept 10 Lectures Begin
Sept 27 Essay Abstract Due
Sept 29 Drop, Penalty 1 Begins
Oct 4 Test 1
Oct 8 Thanksgiving Holiday
Oct 18 Essay Outline Due
Oct 26 50% tuition refund deadline
Nov 8 Test 2
Nov 15 Essay Due
Nov 17 Drop, Penalty 2 Begins
Dec 3 Lectures End
Dec 6 Exam Period starts
Dec 20 Exam Period ends

Disclaimer
The course content and dates given below will be followed as closely as possible, but it is possible that changes may occur. Any changes will be discussed and announced in class and posted on the course webpage. [updated] I encourage students to initiate such discussions during class.

The assessment will remain unchanged.

Rules & Regulations

Illness
If you are ill and are unable to complete one or more course elements you must obtain a “Verification of Illness” form from this URL: http://www.healthservices.uwaterloo.ca/Health_Services/verification.html, have it signed by your doctor and bring it to the Science Undergraduate Office (Earth Sciences and Chemistry Building Room 253).

Accommodation for Missed Course Elements
If an assignment is missed for legitimate academic reasons the remaining assignments will be re-weighted to omit the assignment.

If the term test is missed for legitimate academic reasons the final exam will be worth 70%.

If the exam is missed due to illness and your are in good academic standing (ie you have a passing mark on both the assignments and the tests) you will be assigned an INC and you will be required to write the exam during the following term. It is your responsibility to arrange a mutually convenient time to write the exam. If you are not in good academic standing you will be assigned an DNW for your final mark.

Academic Integrity
“In order to maintain a culture of academic integrity, members of the University of Waterloo community are expected to promote honesty, trust, fairness, respect and responsibility. [Check http://www.uwaterloo.ca/academicintegrity/ for more information.]

Student Grievances
“A student who believes that a decision affecting some aspect of his/her university life has been unfair or unreasonable may have grounds for initiating a grievance. Read Policy #70, Student Petitions and Grievances, Section 4. http://www.adm.uwaterloo.ca/infosec/Policies/policy70.htm When in doubt please be certain to contact the department’s administrative assistant who will provide further assistance.”

Discipline
“A student is expected to know what constitutes academic integrity, to avoid committing academic offenses, and to take responsibility for his/her actions. A student who is unsure whether an action constitutes an offense, or who needs help in learning how to avoid offenses (e.g., plagiarism, cheating) or about ‘rules’ for group work/collaboration should seek guidance from the course professor, academic advisor, or the Undergraduate Associate Dean. For information on categories of offenses and types of penalties, students should refer to Policy #71, Student Discipline, http://www.adm.uwaterloo.ca/infosec/Policies/policy71.htm For typical penalties check Guidelines for the Assessment of Penalties, http://www.adm.uwaterloo.ca/infosec/guidelines/penaltyguidelines.htm”

Appeals
“A decision made under Policy #70 (Student Petitions and Grievances) (other than petitions) or Policy #71 (Student Discipline) a student may appeal the finding, the penalty, or both. A student who believes he/she has a ground for an appeal should refer to Policy #72 (Student Appeals) http://www.adm.uwaterloo.ca/infosec/Policies/policy72.htm”

Students with Disabilities
“Note for students with disabilities: The Office for Persons with Disabilities (OPD), located in Needles Hall, Room 1132, collaborates with all academic departments to arrange appropriate accommodations for students with disabilities without compromising the academic integrity of the curriculum. If you require academic accommodations to lessen the impact of your disability, please register with the OPD at the beginning of each academic term.”

Travel and the Final Examination Period
“Student travel plans are not considered acceptable grounds for granting an alternative examination time. (see http://www.registrar.uwaterloo.ca/exams/finalexams.html).”
Glossary 1. Chapter 6
Summarize the key ideas of Ch. 6 of the textbook.

Assignment 1. Inclined Plane
(a) For a block of mass $m$ on a frictionless inclined plane (angle $\alpha$ to the horizontal, as shown to the left) what is the position, $\vec{r} = (x, y)$, in terms of the generalized coordinate $s$? How about in terms of $x$ or $y$? (b) Use d’Alembert’s principle to find the equation of motion. State clearly your virtual displacement. (c) A block of mass $m$ slides on a frictionless surface which moves horizontally according to $x(t)$. Use d’Alembert’s principle to find the equation of motion. (Hint: The acceleration of the block is not parallel to the incline.)

For what values of $x(t)$ will the block accelerate up the incline? (Hint: Does your answer make sense in the $\alpha \to 0$ limit?)
(d) A block of mass $m$ slides on a frictionless inclined surface of mass $M$ which is free to slide on a frictionless horizontal surface. Use d’Alembert’s principle to find the equations of motion of both the block and the inclined plane. Does your answer make sense in the $\alpha \to 0$ and $M \to \infty$ limits? (e) One of your equations of motion in (d) can be easily integrated. Give a physical interpretation of this integral.

Assignment 2. Wedgie
Consider the square block with a circular segment removed as shown to the right. The side of the block is $b$ and the radius of the circular segment is $a$. The mass of the block is $M$ and it is free to slide without friction on the smooth horizontal surface. A second mass, $m$, is sliding without friction along the circular segment under the influence of gravity. This system has two degrees of freedom. Use $\theta$ and $x$, as indicated on the diagram, as your generalized coordinates. (a) What are the virtual displacements, $\delta \vec{r}_1$ and $\delta \vec{r}_2$, of the masses $M$ and $m$, respectively? Recall that $\delta \vec{r} = \sum_{a=1}^{f} \frac{\partial \vec{r}}{\partial q_a} \delta q_a$. (b) What is the work done in a virtual displacement by the inertial forces and applied forces, $\delta W^{(i)}$ and $\delta W^{(a)}$, respectively? (c) What are the equations of motion corresponding to the virtual displacements $\delta x$ and $\delta \theta$? Simplify your answers so that there are but don’t bother isolating $\ddot{x}$ or $\ddot{\theta}$. 