NIU *PHYS 600 – Classical Mechanics*, Fall 2019

Syllabus

(The latest version of this document can be found under the course's *Content* section on *Blackboard.*)

Catalog Description: Variational principles - Lagrangian and Hamiltonian formulations of Mechanics and their equivalence; symmetries and Noether's theorem; application of variational principles to physical systems such as central force, rigid body motion and oscillation; canonical transformations - Hamilton-Jacobi equation, Poisson and Lagrange brackets; special relativity.

Credit hours: 3

Course objective: We shall start by establishing the Principle of Least Action as the foundation of Classical Mechanics, leading to Euler-Lagrange and Hamilton's equations of motion expressed in terms of generalized coordinates. We'll see how conservation of dynamical quantities, such as energy and momenta, follow elegantly from simple symmetry arguments, and how to treat certain constrained systems. These principles and ideas will then be applied to examine the core systems of classical mechanics consisting of motion of a point mass in a central force field, dynamics of a rigid body comprised of an extended distribution of mass, oscillatory motions of a single point mass and in systems of multiple point masses. This will be followed by a formal development of canonical transformations between systems of generalized coordinates and momenta, the Hamilton-Jacobi theory, commutation relations in the form of Lagrange and Poisson brackets. Along the way we'll gain some insight into the symmetric roles of configuration and momentum spaces and the deep connections to some key concepts in quantum mechanics, to whose development these ideas had contributed. Finally, we'll discuss Special Relativity, whereby time becomes a coordinate, but in a (four-dimensional) Minkowski space, which is characterized by a slightly different metric tensor than the (three-dimensional) Euclidean space that, together with a universal time, formed the basis the preceding sequence. We shall conclude with a cursory look at the relativistically covariant formulation of the principle of least action and the corresponding Lagrangian.

Learning outcome: At the end of the course, a student is expected to have a basic understanding of

- the core theoretical concepts of Classical Mechanics, formally developed using variational principles, in the context of elementary mechanical systems,
- how these concepts serve as a foundation for a wide range of applications in all branches of physics and some areas of engineering,
- the connections between the theoretical framework of quantum mechanics and its roots in classical mechanics,
- the theory of special relativity.

Having completed the course, a student should be able to

- quantitatively solve problems in simple idealized mechanical systems. In particular, they should be well-prepared for the Classical Mechanics portion of the Ph.D. comprehensive examination offered by the department, passing which is a requirement for advancement to candidacy.
- qualitatively analyze, understand and explain design motivations and operational principles of mechanical systems encountered in real life.

Prerequisite: "B" or better in at least a junior-level calculus-based course in classical mechanics (a.k.a "analytical mechanics"). Students are also expected to be familiar with such mathematical concepts and

tools as differential and integral calculus including path integrals, vector algebra, vector calculus, partial differential equations, power (Taylor) series expansions, Legendre and Fourier transformations, matrix properties and manipulations including eigenvalue problems and Jacobian matrices. An introduction to group theory will be given at the beginning of the course.

Course web pages: http://nicadd.niu.edu/~dhiman/phys600/ and, on NIU *Blackboard*. Students are expected to stay up-to-date with the contents of either page throughout the semester.

Class meeting times: M, W 3:30 pm – 4:45 pm

Classroom location: LT 227 (LaTourette)

Instructor: *Prof. Dhiman Chakraborty*. E-mail: dchakrab@niu.edu, dhiman.chakraborty@gmail.com

Instructor Office Hours: M, W 10:30 am – 11:30 am, FW 220 (or by appointment).

Textbook: We will rely most heavily on the notes given in the class. No single textbook comes close enough to being a unique alternative to the notes. The following two are recommended and you should have access to the first one, at least, throughout the semester.

1. Classical Mechanics (3rd ed.) by Herbert Goldstein, Charles P. Poole, and John L. Safko (Addison Wesley, 2001, ISBN-10: 0201657023, ISBN-13: 978-0201657029)
2. Mechanics, Vol 1 (3rd ed.) by L. D. Landau & E. M. Lifshitz (Elsevier, 1976, ISBN: 0750628960)

Other requirements: A calculator will NOT be needed for any part of this course, including homework assignments and exams. Some students may find use of computer programs like Mathematica useful, but they are not necessary and students will not be expected to have access to those.

Assessment (basis of grading):

- **Homework**: 6 assignments (one for every two week of class) – 40 points each. **50%**
- **Class participation**: Not only regular attendance, but also participating in discussions and problem-solving sessions. **10%**
- **Exams**:
  - Midterm – Variational principle, central force, rigid-body dynamics.
  - Final – Comprehensive, including oscillation, canonical transformations, special relativity.

The exams will be given during normal lecture hours.

Grading scheme:

90% and above	85% - 89.99%	80% - 84.99%	75% - 79.99%	70% - 74.99%	63% - 69.99%	55% - 62.99%	40% - 54.99%	Below 40%
A	A-	B+	B	B-	C+	C	D	F

Course Policies, Accommodation and Advice:

- Students are strongly encouraged to seek one-on-one consultation with the instructor for any need related to the course. Phone or e-mail can be used if schedule conflicts prevent in-person meetings. The more time one spends on the course, the more fruitful those sessions will be.
- Efforts will be made to communicate all important announcements relating to the course either by e-mail or by posting on the course pages listed above. In addition to paying prompt attention to notifications, students should make it a habit to visit those pages frequently – at least once the day before each class. However, some announcements may also be made verbally during lectures, and

not communicated in writing. If a student is absent during any part of a lecture, it is their responsibility to follow up with the instructor to be sure that they did not miss any announcement. Ignorance of any announcement – written or verbal – will not count as an excuse.

- Students are strongly encouraged to eschew late arrival to or early departure from the class. However, in case one cannot avoid entering or exiting the lecture hall while a class is in session, they should do so as quietly as possible in order to minimize distraction to others.
- No late submission of homework assignments or papers will be accepted and no make-up work will be offered for missed attendance or exams, *unless* a valid excuse is presented in official writing by an authorized party (e.g. a doctor's note supporting absence from class due to illness or a medical procedure, or the head of a unit requesting advance permission for a student to be absent on certain days – see under **Attendance** below). Such excuses should be submitted in advance of the absence, if possible, but no later than within a week after returning to class.
- To get the maximum out of each lecture, come prepared by reading in advance the part of the textbook that is going to be covered in class that day.
- Last, but not the least, be respectful and courteous to others in the class. Use of "smart" devices - such as laptops, tablets, or smart phones - in class is strongly discouraged. In particular, they must not be used for entertainment or communication while the class is in session. Everyone needs to do his/her part to help make the atmosphere in the classroom as conducive to learning as possible.

Attendance: Attending lectures will be very important to those wishing to do well in the course. In the case of an absence due to unavoidable circumstances, reasonable attempts shall be made to allow the student to make up missed work.

Academic Integrity: Good academic work must be based on honesty. The attempt of any student to present as his or her own work that which he or she has not produced is regarded by the faculty and administration as a serious offense. Students are considered to have cheated if they copy the work of another during an examination or turn in a paper or an assignment written, in whole or in part, by someone else. Students are guilty of plagiarism, intentional or not, if they copy material from books, magazines, or other sources without identifying and acknowledging those sources or if they paraphrase ideas from such sources without acknowledging them. Students guilty of, or assisting others in, either cheating or plagiarism on an assignment, quiz, or examination may receive a grade of F for the course involved and may be suspended or dismissed from the university.

Accessibility for students with disabilities: Students needing disability accommodation for this course should contact the Disability Resource Center as soon as possible. The DRC is located on the 4th floor of the Health Services Building, and can be reached by phone: 815-753-1303 (V) or e-mail: drc@niu.edu.

For a more detailed version of NIU's statements on Attendance, Academic Integrity, and Accessibility, see https://www.niu.edu/accessibility/index.shtml.

Syllabus Change Policy: Every effort has been made to ensure that the syllabus posted on the first day of class is as complete and accurate as possible. However, small changes can sometimes become necessary as the semester progresses. The most up-to-date version of the syllabus (this document) will be available in the *Information* section of the course web page on *Blackboard* throughout the semester.