SCI PHYS 101, Introduction to Physics
Spring semester 2020 - 2021

SCI PHYS 101 Introduction to Physics
Spring 2021

Classroom no: Zoom
Class times: Monday 11:00-13:00, Thursday 11:00-13:00
Instructor: Dr. Leo de Wit
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Office no. & location: Eleanor 2.08
Office hours: by appointment

Zoomlink Monday class

https://universitycollegeroosevelt.zoom.us/j/96134465425?pwd=YmlnLzU0VjNoWm9WeStPcE05SHA3UT09

Zoomlink Thursday class

https://universitycollegeroosevelt.zoom.us/j/96386543328?pwd=T3JMRkdkaVI2a0dDdTA4eXFISFFOZz09

I. Track information

a) Prerequisites for this course: The course does not have any formal prerequisites but is calculus-based. So it is strongly recommended that students complete SCI MATH 101 Calculus for Scientists first. Students enrolling in SCI PHYS 101 also should have taken Mathematics and Physics as exam subjects in high school.
b) This course serves as prerequisite for SCI PHYS 201 Electromagnetism and for SCI PHYS 202 Physical Chemistry. This course is also one of the prerequisites for SCI EART 301 and can (with permission) serve as an alternative perquisite to SCI EART 201 and SCI EART 202. The course will also serve as a prerequisite for Engineering courses; these will be added when these courses are fully developed.
c) Other courses which are relevant to this course - e.g. as part of a minor: SCI MATH 101, SCI PHYS 201, SCI PHYS 202, SCI PHYS 301, SCI PHYS 302.

For further information about the track, please see the track document available on the UCR intranet.

II. Course description

The main subject of SCI PHYS 101 Introduction to Physics is classical mechanics. Classical mechanics is the study of the motion of objects and how they are influenced by a range of forces. The foundations of classical mechanics are Isaac Newton's famous three laws he introduced in his *Philosophiae Naturalis Principia Mathematica* in 1687. This book is generally considered to be one of the most important works in the history of science.

The course covers the key elements of classical mechanics. We describe different types of motion: translational, circular, rotational and oscillatory. We start by studying (structure-less) point masses, but will later also consider extended objects. Common forces as tension, gravity, friction and the elastic spring force are extensively discussed and used. We introduce and use the concepts of kinetic and potential energy. We also emphasize the significance and use of conservation laws for momentum and for energy.

The treatment of classical mechanics will be calculus-based. (Indeed, calculus was developed – by Newton and others – because it is needed to understand classical mechanics.) To learn to apply the concepts of classical mechanics, students will spend a lot of time on solving problems. Students will learn to analyze situations, determine which precise equations follow from what first principles, and solve the obtained equations correctly. In addition to mastering theory, students will also perform a number of experiments.

III. Study Load

This course earns students four credits (equivalent to 7.5 ECTS). The class meets twice a week for two hours. Preparation time is approximately 10 hours per week.

IV. Course materials

The required textbook for the course is:

https://openstax.org/details/books/university-physics-volume-1

This is a free textbook that can be consulted online, but students may also download the book as a pdf file. Many other free online textbooks on classical mechanics are available, some of them can be found at

https://open.umn.edu/opentextbooks/subjects/physics

During the course, the instructor will make further resources available; they will all be published on Moodle.

In this course students will design and perform some experiments. To this purpose, students will have to acquire some materials and/or apps. Details will be discussed with the instructor during the course, but costs will not exceed 10 Euro per person.

V. Course organization and requirements

a) General format of class meetings: all classes start with summarizing the most important results from the previous class(es). Student get the opportunity to ask questions regarding the material discussed earlier in class or regarding homework assignments. The remainder of the first hour is used to discuss new material. The second hour will be used to solve textbook problems. The classes prior to an exam are meant for revision; students can ask questions regarding the material for the upcoming exam, including problems from old exams.
b) The following is expected of students: students are expected to come to class prepared and to participate actively during discussions and problem solving. Students are strongly encouraged to work together on the homework assignments.
c) Students perform the lab experiments that are part of this course outside of class hours in classroom 24 in De Burg. They must adhere to all (safety) rules that apply for this room. Specific activities may only be performed under supervision of a technician –

students will be informed of the specific details at the start of the semester. Students also will be informed during what hours they can work in De Burg unsupervised.

d) Rules for missing classes and deadlines: the rules of the UCR Student Handbook apply. Homework assignments submitted after the deadline will not be corrected and graded. Students missing an exam are expected to notify the instructor before the actual exam and they are expected to retake the exam as soon as possible, preferably in the same week as the scheduled exam.

e) Procedures for communication and use of Moodle: the instructor has an open door policy and tries to be available anytime for discussing any issue in the course. Moodle will be used to make additional material available to students.

This course is subject to UCR academic rules and procedures. Both students and instructors are required to know and follow these rules and procedures.

VI. Assessment

The various assessments contribute to the final grade as follows

25%	Exam 1
30%	Exam 2
30%	Homework assignments
15%	Data analysis of lab experiments

The submissions deadlines and exams are all on the Thursday of the week indicated in the Course schedule shown in section VII. For every test you will receive a grade on a scale from 0 to 100. All these grades will be averaged to determine a final grade on the 0-100 scale. The final letter grade is determined by conversion using the standard UCR table (paragraph 6.3.1 in the student handbook)

<u>Criteria for assessment</u>

Exams

The exams (mainly) contain material of the sections that are covered prior to the exams.. The type and difficulty of the exam questions is similar to the homework assignments on that topic.

Homework assignments

Everybody who wants to acquire proficiency in handling physics must practice a lot. You are expected to hand in all assignments on time. You will receive a grade for every homework set. You can also get credit if you don't have all the right answers – you probably learn most from your mistakes! In case you can't completely solve an assignment, write down where and why you got stuck. (This enables the instructor to help you.) Depending on how far you got with the assignment and on how well you have formulated your problem, you will receive partial credit. For some problems you will need to use a spreadsheet and/or a computer algebra system.

Data analysis for lab experiments

Due to the Covid situation, the means for students performing experiments are greatly reduced. So this semester we will shift the focus to the analysis of data coming out of experiments. For each of the three experiments described below, students will receive an individual spreadsheet with data that are 'measured' in these experiments:

<u>A. Kinematics</u>: make slow motion video of free fall. Analyze data to estimate positions, velocities and accelerations. Determine gravitational force and friction force experienced by falling object.

<u>B. Moment of inertia</u>: Place self-designed object on an oscillating table or attach it to a bifilar pendulum. Determine the moment of inertia from the period of oscillation. Test various positions to verify the parallel axis theorem.

<u>C. Oscillations</u>: Determine period and damping of an harmonic oscillator. Also measure position as a function of time for coupled oscillators and separate the two oscillations.

For each experiment there will be a set of questions related to finding unknown parameters, statistical and/or error analysis, interpretation and conclusions. Students will do all their work in an Excel spreadsheet, and submit this as the report.

VII. Course schedule

Week + dates	Topics to be discussed	Course material	Assignments & assessment
1) Feb 1 & 4	**Motion along a straight line** Kinematics including derivatives and integrals. Dot-notation. Units. Significant figures. Problem solving techniques.	Chap 3+1	
2) Feb 8 & 11	**Motion in two and three dimensions** Cartesian and polar coordinates. Add vectors and decompose vectors in components. For uniform circular motion express kinematic vectors in polar coordinates	Chap 4+2	
3) Feb 15 & 18	**Newton's laws of motion** Examples related to gravity: free fall, sliding along incline, projectile motion, Atwood machines. Free body diagrams	Chap 5	
4) Feb 22 & 25	**Applications of Newton's laws** Solve differential equations for velocity dependent (friction) forces.	Chap 6	Submit Homework set 1
5) Mar 1 & 4	**Work and kinetic energy** Work is integrated dot product of force and position. Definition and use of kinetic energy.	Chap 7	Submit report 'experiment' A
6) Mar 8 & 11	**Potential energy and conservation of Energy** Contour integral of conservative force is zero. Introduce nabla operator: curl of force equals zero, force is gradient of potential. Definition of potential energy and apply conservation of energy	Chap 8	
7) Mar 15 &	**Linear momentum and collision** 1D and 2D collisions and explosions. Elastic and inelastic	Chap 9	Submit Homework set 2

18	collisions. Center of mass and relative position. Applications like rocket equation and conveyer belt.		
8) Mar 22 & 25	Review		Sit Exam I
Mar 29 – Apr 1	S P R I N G B R E A K		
9) Apr 8 only	**Fixed-axis rotation** Find moments of inertia by integrating over object. Compute torque as cross product. Newton's law relates angular acceleration to torque. Review parallels between kinematics for linear and rotational motion.	Chap 10	
10) Apr 12 & 15	**Angular momentum** Rolling motion. Angular momentum is cross product. Analyze conservation of angular and linear momentum in collision between extended objects. Center of percussion.	Chap 11	Submit report 'experiment' B
11) Apr 19 & 22	**Static equilibrium and elasticity** Construct force diagrams and apply that total force and torque is zero. Include stress and strain	Chap 12	Submit Homework set 3
12) Apr 21 & 24	**Gravitation** Derive planetary orbits and Kepler's laws. Use conservation of energy to determine transfer orbits. Explain tides	Chap 13	
13) Apr 26 & 29	**Oscillations** Applications: spring, simple pendulum, physical pendulum. Differential equation of damped, forced oscillator. Reduced mass. Phase diagram. Coupled oscillators: normal nodes and Lissajoux figures	Chap 15	Submit report 'experiment' C
14) May 3 & 6	**Waves** Wave (differential) equation. Energy in waves. Interference. Standing wave	Chap 16	Submit Homework set 4
15) May 10 only	Review		Sit Exam II

VIII. Student learning outcomes

Learning outcomes are color-coded in the following categories:

- Theoretical knowledge
- Performing experiments and analyzing results
- Academic and math skills

Period	Teaching activities	Student is able to do
Period 1 Weeks 1–5	a. Interactive class sessions b. Individual feedback on formative and summative assessment	Comprehend and apply concepts related to kinematics, forces, work and kinetic energy. Create free body diagrams and correctly apply Newton's laws. Apply these principles to both constant and velocity-dependent forces.

	c. Progress meetings on ongoing experiments	Design and conduct experiment, record and analyze data, draw conclusions and (briefly) report results. Solve problems in a structured and logical way. Correctly use different coordinate systems and solve first order differential equations. Clearly communicate solution.
Period 2 Weeks 6–10	a. Interactive class sessions b. Individual feedback on formative and summative assessment c. Progress meetings on ongoing experiments	Comprehend and apply concepts related to position-dependent forces, and potential energy. Identify when conservation of momentum and/or energy applies, and apply conservation laws. Correctly use concepts of torque, moment of inertia and angular momentum to describe rotational motion, both around fixed and non-fixed axes. Design and conduct experiment, record and analyze data, draw conclusions and (briefly) report results. Solve problems in a structured and logical way. Correctly use cross products, vector calculus, and perform (multiple) integrals. Clearly communicate solution.
Period 3 Weeks 11–15	a. Interactive class sessions b. Individual feedback on formative and summative assessment c. Progress meetings on ongoing experiments	Construct force diagrams and solve unknowns from static conditions. Comprehend gravitational forces and derivation of Kepler's laws, and apply these principles in basic calculations. Comprehend and apply concepts related to harmonic oscillations and both traveling and standing waves. Design and conduct experiment, record and analyze data, draw conclusions and (briefly) report results. Solve problems in a structured and logical way. Correctly use polar coordinates and solve various second order (coupled) differential equations. Clearly communicate solution.