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JINAN UNIVERSITY
Fundamentals of Physics I (With Lab)

Lecturer: Dr. Stefan Kautsch
Time: Monday through Friday (July 2, 2018 - August 3, 2018)
Office hours: 2 hours (according to the teaching schedule)
Contact hours: 60 (50 minutes each)
Credits: 4
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Course Description

This course is an introduction to physics. The main emphasis will be on the branch of physics known as *mechanics and Dynamics*. This is the study of motion and the causes of motion through the applications of fundamental principles of physics. We begin with kinematics, the quantitative description of the motion. We then build on kinematics to learn how and why motion occurs, through the application of Newton's laws of dynamics. Many examples will be considered as we explore the properties of specific forces and the details of the motion they bring about. The next step will be to describe physical processes in terms of energy and momentum, quantities that are always "conserved." Conservation laws allow us to solve problems in mechanics that would be very difficult by other techniques and provide a powerful approach to the analysis of physical systems in general. We then will extend our understanding of motion to the kinematics and dynamics of rotation. Finally, we will briefly study some of the physical properties of solids and fluids. By the end of this session, you should have a deeper understanding of the phenomena occurring in your surrounding physical world. You should have a clearer picture of the behavior of the universe on the largest (cosmic) scale, and on the smallest (subnuclear) scale. You should also understand more about the physics of biological systems, including your own body. In addition, you should be more competent at measurement and quantitative reasoning concerning physical processes.

Module I (***Introduction and Vectors***) discusses a few mathematical concepts and techniques that will be used throughout the course, such as dimensional analysis, significant figures, unit systems, mathematical notation, and coordinate systems. This module will also define the basic quantities of measurement in mechanics (length, time, mass and their SI units), and discuss the difference between scalar and vector quantities, as well as the properties and components of vectors.

Module II (***Motion in One and Two Dimensions***) investigates kinematics, the part of mechanics that describe motion without regard to the causes of motion. We will start by describing motion along a straight line and define the concepts of velocity and acceleration. We will then investigate the motion of free-falling bodies influenced by gravity, and conclude this module by exploring projectile motion.

Module III (***The Laws of Motion***) is an introduction to the classical mechanics. Here we shall use the concepts of force and mass to describe the change in the motion of an object, relate mass and acceleration, and explore the laws of motion proposed by Kepler and Newton. We will conclude this module by investigating some of the applications of Kepler's and Newton's laws and discuss other forces.

Module IV (***Circular Motion and the Law of Gravity***) deals with circular motion, a specific type of two-dimensional motion. We will explore the concepts of angular velocity, angular acceleration, and radial force, and introduce Newton's universal law of gravity, one of the fundamental laws in nature. We will discuss how this law of gravity, together with the laws of motion, enables us to understand a variety of familiar phenomena, including the orbital motion of satellites and celestial bodies.

Module V (***Work and Energy***) will focus on the mechanical forms of energy. We will introduce the concepts of work, power, and kinetic and potential energy, and explore how the ideas of work and energy can be used in place of Newton's laws to solve certain problems. We will conclude this module by discussing the law of conservation of energy and applying it to various problems.

Module VI (***Momentum and Collisions***) will introduce the concepts of momentum and impulse, and investigate how these concepts relate to the law of conservation of momentum. We will then apply this understanding to explain a number of elastic and inelastic collisions.

Module VII (***Rotational Motion***) will build on concepts from module IV by examining the relationship between angular velocity, angular acceleration, and the forces that produce rotational motion. We will also explore the conditions for equilibrium, and the relationship between torque, rotational inertia, and conservation of momentum.

Module VIII (***Solids, Fluids, and Fluid Dynamics***) will explore the states of matter and some properties of solids and fluids (liquids and gases). We will investigate concepts of density and pressure, explore buoyant forces and the Archimedes' principle, then understand how these properties and concepts explain the behavior of fluids, both the fluids at rest and the fluids in motion.

Required Textbook

The Physics of Everyday Phenomena: A Conceptual Introduction to Physics, 8th edition (2014), by W. Thomas Griffith and Juliet Brosing. Publisher: McGraw-Hill, ISBN 978-0073513904.

Course Hours

The course has 25 sessions in total. Each class session is 120 minutes in length. The course meets from Monday to Friday.

Assessment

Your final grade is based on the following components:

Lab Activities	25%
Quizzes/Homework	20%
Midterm Exam	25%
Final Exam	30%
Total	100%

Grading Scale

The instructor will use the grading system as applied by JNU:

Definition	Letter Grade	Score
Excellent	A	90-100
Good	B	80-89
Satisfactory	C	70-79
Poor	D	60-69
Failed	E	Below 60

Policies

I want you to succeed in this course and at Jinan University. Here are some tips how to be successful in class: attend all lessons on time, prepare yourself by reading the textbook and not only rely on my slides, prepare your own study plan, stay awake during class. I encourage you to come see me during office hours or to schedule an appointment with questions or concerns about the course, and the universe. Any use of an electronic computational/communication device is strictly prohibited. Using such a device will result in a 5 point penalty on your final grade. Audio and/or video recording during, before, and after the course is strictly forbidden. There will be no makeup exams. Missed or late homework assignments and/or quizzes and reports will receive zero points.

Class Schedule

Week 1

Lecture 1: Physics – The Foundation of Nature
Lecture 2: Motion in Space and Time
Lecture 3: Motion in Gravitational Fields
Lecture 4: Kepler's and Newton's Laws
Lab 1: Measurements, Velocity, and Acceleration

Week 2

Lecture 5: A Variety of Daily-life Forces
Lecture 6: Gravitation in the Universe
Lecture 7: Orbits and Circular Motion
Lecture 8: Work and Energy
Lab 2: Newton's and Kepler's Laws

Week 3

Lecture 9: Momentum and Impulse
Lecture 10: Collisions
Mid-Term Exam
Lecture 11: Conservation of Momentum
Lab 3: Conservation of Energy and Momentum

Week 4

Lecture 12: Rotational Motion
Lecture 13: May the Torque be with You
Lecture 14: Angular Momentum
Lecture 15: Balance and Center of Gravity

Lab 4: Rotational Motion

Week 5

Lecture 16: States of Matter

Lecture 17: Fluids Dynamics and Archimedes' Principle

Lab 5: Buoyancy

Final Exam Review

Cumulative Final Exam

Lab Experiments

The students will form groups of four team members at the beginning of the first lab. The groups will perform the experiments together, but each individual student turns in a lab report.

Materials:

Four toy cars (e.g., Lego, matchbox)

Scale

Meter stick or measuring tape

Ruler

Rubber bands for the toy cars

Straight drinking glasses or cans

Lab 1: Measurements, Velocity, and Acceleration: Experiment vs Theory

Students learn how to perform scientific measurements of displacement and time, and how to determine the statistics of the measurements (mean, standard error and deviation, percentage difference and error). The students will be also introduced to concepts of velocity and constant acceleration and how to compare measurements from experiments to theoretical predictions:

A) A toy can will roll for 10 meters and the time will be measured by the students. Each group will perform five measurements of the time using the stopwatches on their cell phones. They will then calculate the average velocity of the toy car and its statistics.

B) The track from A) will be divided into four equal segments, and the velocity of the toy car will be measured in each segment as shown in A). This will be used to calculate the acceleration of the car. Then the initial velocity of the toy car will be calculated using the equation for constant acceleration and compared to the measured velocity in the first segment, and the percentage difference will be derived.

Lab 2: Newton's and Kepler's Laws

This lab is a workshop with the aim of applying the concept of gravitational force to predict the orbital motions of planetary bodies in space. Students will also learn how to read data tables and to derive physical laws using the provided data.

A) This part of the lab consists of a worksheet in order to discover Kepler's Laws and how they can be translated into Newton's laws of inertial and gravitational force. Students will draw different orbits with different eccentricities and compare the orbital speeds of the objects at different sections of the orbit.
B) Students will use a table containing the orbital distance, orbital period, and planet mass of the planets in the Solar system. These data will be used to derive Kepler's third law and the concept of gravitation.

Lab 3: Conservation of Energy and Momentum

The classroom will be used to set up the same ten meter track from the first experiment. Two toy cars will be engaged in elastic and inelastic collissions in ordert to measure the conservation of energy and momentum.

A) The cars will be set up with a rubber band bumper. One car is accelerated towards the collision with the other car (originally at rest). The student teams will measure the velocity (as in Lab 1) for both cars before and after the collisions.
B) The same measurements will be performed for the toy cars without the rubber bumpers. The conservation of energy and momentum in case A) and B) will be calculated and compared.

Lab 4: Rotational Motion

The lab teams engage in a workshop to use the concepts of circular and rotational motion and gravitation to measure the mass of Jupiter.

A) Lab teams find the measurements of the periods and semi-major axes of the Galilea moons of Jupiter. The collection of those data is the responsibility of each lab group. The data can be found using various online sources, such as planetarium software (e.g., World Wide Telescope, Stellarium)
B) The equation of radial (also known as centripetal) force and the universal law of gravitation will be combined and used to derive the satellite equation. Then this formula will be used to derive Jupiter's mass from the collected moon orbit data and the compared to the textbook value of Jupiter. The percentage difference of the masses will be derived.

Lab 5: Buoyancy

This lab will engage the student teams in the concepts of fluids, pressure, and buoyance. This will be done by measuring the relation between depth and pressure in a liquid. Students will also learn how to plot data, draw a linear regression line, and derive a physical relation law from the slope of this line.

A) The mass of a couple of graduated cylinders, cans, or glasses will be measured on a scale with and without water. The difference is the mass of the water columns. Then the mass of the water columns is measured for three more column heights. The cross-section area of the column is derived from the radius of the glass.

B) The pressure on the bottom of each column height is derived. Additionally, students draw a mass (kg) vs. area (m^2) graph, fit a linear regression line on the data, and calculate the slope of the graph.

Academic Honesty

Jinan University defines academic misconduct as any act by a student that misrepresents the students' own academic work or that compromises the academic work of another scholastic misconduct includes (but is not limited to) cheating on assignments or examinations; plagiarizing, i.e. misrepresenting as one´s own work any work done by another; submitting the same paper, or substantially similar papers, to meet the requirements of more than one course without the approval and consent of the instructors concerned; sabotaging another´s work within these general definitions, however, instructors determine what constitutes academic misconduct in the courses they teach. Students found guilty of academic misconduct in any portion of the academic work face penalties ranging from lowering of their course grade to awarding a grade of E for the entire course.