PHYS 204: Physics for Scientists and Engineers I (Rev. 3)

Physics 204: Physics for Scientists and Engineers I is a calculus-based course that provides introduction to classical mechanics. PHYS 204, combined with PHYS 205, gives the equivalent of one year in introductory physics recommended for science, engineering, and pre-med students.

Prerequisite

MATH 260 or MATH 265 or equivalent.

Course Syllabus

PHYS 204

Learning Outcomes

Upon successful completion of this course, you should be able to

- convert between different units and express a physical quantity in scientific notation using the appropriate number of significant digits.
- explain the relationships between time, displacement, velocity, and constant acceleration and use calculus to solve kinematic problems in one or two dimensions.
- analyze and solve dynamic problems using vector calculus, Newton's three laws of motion, and frictional forces.
- state the work–kinetic energy theorem and the conservation of energy principle and use calculus to analyze systems that involve conservative and nonconservative forces.
- state the conservation of linear momentum principle and apply it to solve problems that involve one- and two-dimensional (elastic and inelastic) collisions.
- define center of mass and torque vector and solve problems that involve static equilibrium of extended bodies.
- analyze and solve problems that involve the kinematics and dynamics of rotational motion and the conservation of angular momentum principle.
- state Hooke's law and describe elastic properties of solids and apply formulas for calculating Young's modulus, bulk modulus, and shear modulus.
- state Newton's law of universal gravitation and define gravitational potential and apply them to solve problems involving the force of gravity and satellite motion.
- demonstrate skills related to performing simple experiments in classical mechanics, including experimental setup, data acquisition, data analysis, and communication of scientific results.

Course Outline

Physics 204 consists of the following thirteen units:

- **Unit 1:** Physics and Measurement
  - Standards of Length, Mass, and Time
  - Matter and Model Building
  - Dimensional Analysis
  - Conversion of Units
  - Estimates and Order-of-Magnitude Calculations
  - Significant Figures

- **Unit 2:** Motion in One Dimension
  - Position, Velocity, and Speed
  - Instantaneous Velocity and Speed
  - Analysis Model: Particle Under Constant Velocity
  - Acceleration
  - Motion Diagrams
  - Analysis Model: Particle Under Constant Acceleration
  - Freely Falling Objects

- **Unit 3:** Vectors
  - Coordinate Systems
  - Vector and Scalar Quantities
  - Some Properties of Vectors
  - Components of a Vector and Unit Vectors

- **Unit 4:** Motion in Two Dimensions
  - The Position, Velocity and Acceleration Vectors
  - Two-Dimensional Motion with Constant Acceleration
  - Projectile Motion
  - Relative Velocity and Relative Acceleration

- **Unit 5:** The Laws of Motion
  - The Concept of Force
  - Newton's First Law and Inertial Frames
  - Mass
  - Newton's Second Law
  - The Gravitational Force and Weight
  - Newton's Third Law
  - Analysis Models Using Newton's Second Law
  - Forces of Friction

- **Unit 6:** Circular Motion
  - Analysis Model: Particle in Uniform Circular Motion
  - Tangential and Radial Acceleration
  - Extending the Particle in Uniform Circular Motion Model
  - Nonuniform Circular Motion

- **Unit 7:** Energy of a System
  - Systems and Environments
  - Work Done by a Constant Force
  - The Scalar Product of Two Vectors
  - Work Done by a Varying Force
  - Kinetic Energy and the Work–Kinetic Energy Theorem
  - Potential Energy of a System
  - Conservative and Nonconservative Forces
  - Relationship Between Conservative Forces and Potential Energy

- **Unit 8:** Conservation of Energy
  - Analysis Model: Nonisolated System (Energy)
  - Analysis Model: Isolated System (Energy)
  - Situations Involving Kinetic Friction
  - Changes in Mechanical Energy for Nonconservative Forces
  - Power

- **Unit 9:** Linear Momentum and Collisions
  - Linear Momentum
  - Analysis Model: Isolated System (Momentum)
  - Analysis Model: Nonisolated System (Momentum)
  - Collisions in One Dimension
  - Collisions in Two Dimensions
  - The Center of Mass
  - Systems of Many Particles
  - Rocket Propulsion

- **Unit 10:** Rotation of a Rigid Body About a Fixed Axis
  - Angular Position, Velocity, and Acceleration
  - Analysis Model: Rigid Object Under Constant Angular Acceleration
  - Angular and Translational Quantities
  - Torque
  - Analysis Model: Rigid Object Under a Net Torque
  - Calculation of Moments of Inertia
  - Rotational Kinetic Energy
  - Energy Considerations in Rotational Motion
  - Rolling Motion of a Rigid Object

- **Unit 11:** Angular Momentum
  - The Vector Product and Torque
  - Analysis Model: Nonisolated System (Angular Momentum)
  - Angular Momentum of a Rotating Rigid Object
  - Analysis Model: Isolated System (Angular Momentum)

- **Unit 12:** Static Equilibrium and Elasticity
  - Analysis Model: Rigid Object in Equilibrium
  - More on the Center of Gravity
  - Examples of Rigid Objects in Static Equilibrium
  - Elastic Properties of Solids

- **Unit 13:** Rotation of a Rigid Body About a Fixed Axis
  - Newton's Law of Universal Gravitation
  - Free-Fall Acceleration and the Gravitational Force
  - Analysis Model: Particle in a Field (Gravitational)
  - Kepler's Laws and the Motion of Planets
  - Gravitational Potential Energy
  - Energy Considerations in Planetary and Satellite Motion

Course Materials

- **eText:** Serway, Raymond A. and Jewett, John W., Jr. (2014). Physics for scientists and engineers (9th ed.). Boston, MA: Cengage Learning.
- **AU Study Guide:** Physics 204 Study Guide (2019), Athabasca University.

In this revision of PHYS 204, the Study Guide merges relevant sections of the eText with the AU-produced lab experiments, assignment questions, and detailed solutions for problems selected from the end of each chapter in the eText. In addition, the Study Guide provides solutions to supplementary problems selected from OpenStax College Physics.

The Study Guide has been prepared in html code and uses the open-source MathJax JavaScript display engine. This combines the accessibility of html with the beauty and convenience of the LaTeX mathematical equations and symbols. Special effort has also been made to make the learning materials accessible on mobile devices.

In addition to a number of dynamic and interactive diagrams developed using Mathematica, one important feature is the inclusion of interactive activities using the free simulations of the PhET project. This allows you to watch (and interact with) objects moving in real time. The Study Guide also includes 3D animation videos created using text-to-speech technology software (State) developed by Xtranormal Technology Inc.

Laboratory Component

The lab is a mandatory component of the PHYS 204 course and it is worth twenty percent (20%) of your final grade. The six experiments in the home lab are meant to go with the course material and may be conducted in the place of your choice.

- **Lab 1:** Graphical Analysis
- **Lab 2:** Kinematics in One Dimension

- **Lab 3:** Projectile Motion
- **Lab 4:** Hooke's Law
- **Lab 5:** Collision in Two Dimensions
- **Lab 6:** Rolling Motion

Equipment and Materials

The lab component is designed to provide quality hands-on physics experiments that are based on video analysis of moving objects. A digital video camera (e.g., a smartphone) and a personal computer are required for data collection and analysis, and for the production of lab reports. In addition, you are expected to provide some necessary materials, considered common and safe household items.

The following is a list of the household items required:

- digital camera (e.g., a smartphone)
- ruler (or measuring tape)
- rubber band (or spring)
- small container (e.g., a small plastic bag)
- 10 identical coins
- adhesive tape
- two identical spherical objects (e.g., glass marbles, billiard balls, tennis balls)
- a hoop (e.g., empty food can, short pipe)
- a solid cylinder (e.g., unopened food can, cylindrical candle, hockey puck)
- a spherical shell (e.g., tennis ball, ping-pong ball)
- a solid sphere (e.g., glass marble, billiard ball)
- an inclined surface (e.g., wooden board, large hard-cover book, binder, coffee table)

Lab Software

The home lab experiments of PHYS 204 require the Tracker software or, alternatively, Logger *Pro* 3 by Vernier. Both software can be used to perform video analysis of moving objects and generate graphical representations of experimental data.

Lab Report

Lab reports are an effective way of communicating important experimental results and conclusions. There is little point in doing a wonderful experiment with great results if you cannot effectively communicate your method and findings to others. Although you have some freedom in preparing your lab report, make sure to include the following sections:

- **Cover Page** – Create a cover page for your lab report that includes the title of the experiment, your name, student ID, and date.
- **Introduction** – Provide a concise theoretical background.
- **Procedure** – Describe your procedure in your own words.
- **Pictures** – Include clear pictures (and/or videos) of your setup.
- **Data** – Organize and present the data you collect in the experiment. Also provide a description of the behaviour and apparent trend of the collected data.
- **Analysis and Discussion** – Give clear and detailed analysis of your data. Make sure to include sample calculations, especially for calculated columns in data tables. You may also need to produce graphs and perform appropriate fits. Do not forget to provide reasonable error analysis of your results and a discussion of measurement uncertainties.
- **Conclusion** – Present a summary of your findings and results.
- **Questions** – Provide detailed answers to the questions at the end of the lab.

Lab Safety

Appropriate care should be taken due to moving objects and other potentially hazardous situations and materials. The level of risk involved in doing these labs is comparable to that of day-to-day activities and care has been taken to avoid suggesting activities that produce hazards. It is your decision to proceed with any experiment and in making that decision, you control your own situation and assume any risks involved.

You are expected to complete the Workplace Hazardous Materials Information System (WHMIS) training and acknowledge completion of WHMIS by checking the box on the course home page and uploading your certificate of completion prior to starting the labs.

Evaluation

Your final grade in PHYS 204 is based on the marks you achieve in two tutor-marked assignments, six lab reports, and two invigilated exams. You must achieve at least fifty per cent (50%) on the final examination and on the lab component, and an overall course grade of at least fifty per cent (50%) to pass the course. Students who do not achieve a minimum passing grade on the final exam may write a supplemental examination. There is a fee for this service.

The following chart summarizes the evaluation activities and their credit.

Activity	Credit Weight
Assignment 1	10%
Assignment 2	10%
Lab 1	3.0%
Lab 2	3.4%
Lab 3	3.4%
Lab 4	3.4%
Lab 5	3.4%
Lab 6	3.4%
Midterm Exam	20%
Final Exam	40%
Total	**20%**

Assignments

You are expected to do two assignments, which are worth 20% of your final grade.

- Assignment 1 (covers Units 1–6)
- Assignment 2 (covers Units 7–13)

Although you may find it convenient to answer the assigned problems in the briefest possible way, you should get into the habit of showing all your work. This strategy enables the marker to identify where you are having trouble with concepts or mathematical skills. Once you have answered all the questions in a particular assignment, submit it for marking by uploading it to the appropriate drop box. Scanned copies of your handwritten solutions are acceptable.

Examinations

You are required to write two online-invigilated exams (midterm and final). Please request your exams well in advance of the dates you intend to complete them. Make sure you have your student ID number and picture identification with you at your exam.

The midterm exam covers Units 1–6 and it is worth 20% of the total course mark. The final exam covers all units (1–13), with emphasis on the second half of the course, and it is worth 40% of the total course mark. These are closed-book exams to be completed online without any printed material or electronic devices, other than a calculator. Key formulas will be provided in the online exam. Any scrap paper you use during the exam must be destroyed at the end of the exam.

Course Coordinator

Farook Al-Shamali, Ph.D.
Email: farooka@athabascau.ca
Phone: (780) 452-5720 (local calls), 1-866-406-3061 (toll free)