PHYS 205: Physics for Scientists and Engineers II (Rev. 1)

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

Prerequisite

PHYS 204 or (PHYS 200 and MATH 265) or equivalent.

Course Syllabus

PHYS 205
Promotional Video

Learning Outcomes

- Upon successful completion of this course, you should be able to
- use Coulomb's law and vector calculus to compute electric forces and fields due to static point charges and simple charge distributions.
- apply Gauss's law to calculate and map the electric fields for symmetric charge distributions.
- define electric potential and electric potential energy and use calculus to solve relevant problems.
- explain the concepts of electric current, voltage, resistance and capacitance, along with Ohm's law, and use them to solve problems involving simple DC circuits.
- outline the Biot-Savart and Ampère's laws and use vector calculus to describe the magnetic fields generated by simple current distributions.
- describe and calculate the forces experienced by electric currents and moving point charges in an external magnetic field.
- define Faraday's and Lenz's laws and solve problems involving induced electromotive forces.
- explain inductance and analyze circuits involving resistors, capacitors and inductors when connected across AC sources.
- describe Maxwell's equations and solve problems involving electromagnetic radiation, including polarization, intensity and transported energy.
- demonstrate skills related to performing simple experiments in electricity and magnetism, including experimental setup, data acquisition, data analysis and communication of scientific results.

Course Outline

Physics 205 consists of the following twelve units:

- **Unit 1:** Electric Fields
  - Properties of Electric Charges
  - Charging Objects by Induction
  - Coulomb's Law
  - Analysis Model: Particle in a Field (Electric)
  - Electric Field of a Continuous Charge Distribution
  - Electric Field Lines
  - Motion of a Charged Particle in a Uniform Electric Field

- **Unit 2:** Gauss's Law
  - Electric Flux
  - Gauss's Law
  - Application of Gauss's Law to Various Charge Distributions
  - Conductors in Electrostatic Equilibrium

- **Unit 3:** Electric Potential
  - Electric Potential and Potential Difference
  - Potential Difference in a Uniform Electric Field
  - Electric Potential and Potential Energy Due to Point Charges
  - Obtaining the Value of the Electric Field from the Electric Potential
  - Electric Potential Due to Continuous Charge Distributions
  - Electric Potential Due to a Charged Conductor
  - The Millikan Oil-Drop Experiment

- **Unit 4:** Capacitance and Dielectrics
  - Definition of Capacitance
  - Calculating Capacitance
  - Combinations of Capacitors
  - Energy Stored in a Charged Capacitor
  - Capacitors with Dielectrics
  - Electric Dipole in an Electric Field
  - An Atomic Description of Dielectrics

- **Unit 5:** Current and Resistance
  - Electric Current
  - Resistance
  - Resistance and Temperature
  - Superconductors
  - Electrical Power

- **Unit 6:** Direct-Current Circuits
  - Electromotive Force
  - Resistors in Series and Parallel
  - Kirchhoff's Rules

- RC Circuits
- Household Wiring and Electrical Safety

- **Unit 7:** Magnetic Fields
  - Analysis Model: Particle in a Field (Magnetic)
  - Motion of a Charge Particle in a Uniform Magnetic Field
  - Applications Involving Charge Particles Moving in a Magnetic Field
  - Magnetic Force Acting on a Current-Carrying Conductor
  - Torque on a Current Loop in a Uniform Magnetic Field
  - The Hall Effect

- **Unit 8:** Sources of the Magnetic Field
  - The Biot-Savart Law
  - The Magnetic Force Between Two Parallel Conductors
  - Ampère's Law
  - The Magnetic Field of a Solenoid
  - Gauss's Law in Magnetism
  - Magnetism in Matter

- **Unit 9:** Faraday's Law
  - Faraday's Law of Induction
  - Motional emf
  - Lenz's Law
  - Induced emf and Electric Fields
  - Generators and Motors

- **Unit 10:** Inductance
  - Self-Induction and Inductance
  - RL Circuits
  - Energy in a Magnetic Field
  - Mutual Inductance
  - Oscillations in an LC Circuit
  - The RLC Circuit

- **Unit 11:** Alternating-Current Circuits
  - AC Sources
  - Resistors in an AC Circuit
  - Inductors in an AC Circuit
  - Capacitors in an AC Circuit
  - The RLC Circuit
  - Power in an AC Circuit
  - Resonance in a Series RLC Circuit
  - The Transformer and Power Transmission

- **Unit 12:** Electromagnetic Waves
    - Displacement Current and the General Form of Ampère's Law
    - Maxwell's Equations and Hertz's Discoveries
    - Plane Electromagnetic Waves
    - Energy Carried by Electromagnetic Waves
    - Production of Electromagnetic Waves by an Antenna
    - The Spectrum of Electromagnetic Waves

Course Materials

- **eText:** Serway, Raymond A. and Jewett, John W., Jr. (2014). Physics for scientists and engineers (9th ed.). Boston, MA: Cengage Learning.
- PHYS 205 **Study Guide** (2015), Athabasca University.
- PHYS 205 **Assignment Manual** (2015), Athabasca University.
- PHYS 205 **Home Lab Manual** (2015), Athabasca University.

Laboratory Component

PHYS 205 includes a compulsory lab component that requires students to perform six hands-on lab experiments in a place of their choice. Essential tools and equipment are packaged in the Home Lab Kit. The student is expected to provide some additional common household materials. The PHYS 205 Lab Manual explains the following experiments.

- **Lab 1: Coulomb's Law** – The basic idea is to charge two Styrofoam balls and determine the repulsive electric forces when the balls are at different distances (r) from each other.
- **Lab 2: Ohm's Law and Resistivity** – This experiment consists of two parts. The first involves testing Ohm's law using a standard resistor, while the second part examines the relation between length and resistance of a Nichrome wire.
- **Lab 3: RC Circuit** – This experiment involves constructing an RC circuit and observing the voltage build-up across the capacitor during the charging process. It also involves observing the voltage decay during the discharging process and investigating the effect of the resistance connected.
- **Lab 4: Magnetic Field of a Solenoid** – This experiment involves constructing a solenoid and measuring the strength of the magnetic field inside versus the flowing current, which should allow for estimating the magnetic permeability of free space.
- **Lab 5: Electric Motor** – In this experiment the student constructs a simple electric motor and demonstrate how it works including an explanation of the torques involved.
- **Lab 6: Lab Project** – In this lab, the student has the freedom to choose a suitable experiment or project, provided it is related to one of the main topics discussed in the course. The project should answer a nontrivial question and have a narrow scope suitable for a short experiment.

Equipment and Materials

Part of the material and equipment required for the experiments in this manual are packaged in a kit form, which can be borrowed from the Athabasca University (AU) Science Lab. The PHYS 205 lab kit should contain the items listed below. You are expected to provide additional material in the form of common household items.

The following is a list of the lab kit contents:

- Three Styrofoam balls
- Differential voltage probe
- Current probe
- Magnetic field sensor
- Go!Link connection
- D-size battery holder
- Circuit switch
- Capacitor (470µF)
- Five resistors (values 15Ω to 50Ω)
- Three resistors (values 5kΩ to 15kΩ)
- Nichrome wire (about 1m long)
- Enameled (or insulated) copper wire (about 1.5m long)
- Five connection wires
- Permanent magnet

The following is a list of the household items required:

- Two pencils
- Dental floss
- Clear adhesive tape
- Two D-size batteries

- Small carton box (e.g., 2-litre juice box)
- Eleven small-size nails (approximately 1" long)
- A cylindrical object slightly wider than the magnetic sensor
- Two metallic forks
- Digital camera digital camera (e.g., a smartphone)

Lab Software

The home lab experiments of PHYS 205 will require the Logger *Pro* 3 software by Vernier. The software provides interface with sensors, which allows monitoring real-time data on the computer. The software is also used in the analysis of experimental data and production of graphs for the lab report.

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.
- **References** – Include a complete list of all the sources used in preparing the lab report.

Lab Safety

Appropriate care should be taken with moving objects and other potentially hazardous situations and materials, such as sharp objects. No materials or equipment used are to be connected to electrical power outlets. Use only low-voltage batteries as instructed. The level of risk involved in doing these labs is comparable to that of day-to-day activities. Care has been taken to avoid suggesting activities which 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 205 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%
Lab 2	3%
Lab 3	3%
Lab 4	3%
Lab 5	3%
Lab 6	5%
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 7–12)

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 (1–12), 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

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