Physics 2910G - Introduction to Physical Measurement

Winter 2024, v. 01/16/2024

Lectures:

Laboratories:

Prerequisite(s): Physics 1201A/B or Physics 1401A/B or Physics 1501A/B or the former Physics 1301A/B, each with a minimum mark of 60%, or the former Physics 1028A/B with a minimum mark of 80%; Physics 1202A/B or Physics 1402A/B or Physics 1502A/B or the former Physics 1302A/B, each with a minimum mark of 60%, or the former Physics 1029A/B with a minimum mark of 80%; a minimum mark of 60% in each of (Calculus 1000A/B or Calculus 1500A/B or Numerical and Mathematical Methods 1412A/B or the former Applied Mathematics 1412A/B) and (Calculus 1301A/B or Calculus 1501A/B or Numerical and Mathematical Methods 1414A/B or the former Applied Mathematics 1414A/B), or in the former Applied Mathematics 1413. Integrated Science 1001X with a minimum mark of 60% can be used in place of Physics 1202A/B and Calculus 1301A/B.

Instructor: Professor Lyudmila Goncharova
Office: Physics & Astronomy Building Office
hours: by appointment lgonchar@uwo.ca

Course website: OWL site for this course: https://owl.uwo.ca/portal

Textbooks: selected chapters of the following textbooks will be on OWL/Resources/Books

1. M. Nahvi, J.A. Edminister, Basic circuit analysis (4^{th} ed.), Schaum's Outline Series, McGraw-Hill, New York, 2011 – ISBN: 978- 0-07-142582-9.
2. P. Horowitz, W. Hill, The art of electronics (3^{rd} ed.), Cambridge University Press, New York, 2015 – ISBN 978-0-521-80926-9.
3. J.R. Taylor, An introduction to error analysis (2^{nd} ed.), University Science books, Sausalito, 1997 – ISBN 0-935702-75-X.

Other support material will be uploaded to the course website**.**
Hardcover lab notebook: You will also need a lab notebook, it can be purchased in the UCC bookstore.

Course content (see calendar in Appendix I) includes time slots with lectures, tests, lab instructions, laboratories, research lab visits. Lecture material will cover electric circuits, nuclear physics laboratory techniques, and data analysis. Note the course is designated "G" – report writing forms a major component.

Evaluation:

Tests/assignments (sum of all test marks, see details below)		**20 %**
Laboratory reports with pre-labs and lab notebooks	**2*3 + 9*4 + 4=**	**46 %**

Team project and project presentation	**10 %**
Final exam	**24 %**

Tests/assignments: There will be four tests during specific days (see Appendix I). Tests are composed of numeric and/or symbolic problems, and can be completed in two different modes:
(a) "<u>Open book mode</u>" in class: The student completes the open-book test in 50 min and submits it in to the Instructor/TA. **Max: 5.0% per test**
(b) "<u>Assignment mode</u>" (Deadline: Friday, 9:20 am): The student completes the test as an HW assignment and uploads it to OWL electronically. **Max: 3.0% per test**

Textbooks, notes and a <u>non-programmable</u> pocket calculator are permitted during the test but NO cell phones, or any other electronic devices are allowed. The "*open-book mode*" is a preferable way to submit tests. If you decide to submit test in "*assignment mode"*, please convert all pages into one PDF file and upload this single file on OWL.

Laboratory reports
<u>All laboratory experiments</u> must be satisfactorily completed in order to pass the course and *<u>all lab reports must be uploaded to the OWL website</u>*. Specific make-up dates for each lab experiment have been anticipated, see Appendix II and related make-up policy.

<u>Pre-lab</u> component is a simple preparation write-up for each lab. It must be written in your lab notebook before you come to the lab, and it typically consists of 2-3 sentences summarizing your goals for the lab, and have equipment and component list. You can start doing lab only after pre-lab is signed by your TA. 1 point penalty will be applied in case if you don't have pre-lab ready <u>before your start</u>, for each lab.

<u>Laboratory reports</u> are due at the dates listed in Appendix II. Reports must be typed, no head-written reports are accepted. There will be 3 short (2 % each) and 4 long (9 % each) reports.
Late reports will be accepted with **penalties**:
(a) Your report mark will be reduced by 10% *right after deadline*: with maximum of 1.8% for short reports and 8.1% for long reports.
(b) Very late report marks will be divided by 2 in two weeks after the deadline (1% for short and 4.5% for long reports).
All of the reports need to be uploaded to OWL by April 8, 2024, 11:55pm in order to pass the course and no lab reports will be accepted after that date without special permission.

Team project and project presentation (3+3+4=10 points).
This year we will be learning how to use Arduino kits to performing basic measurements, working in teams. Preliminary project ideas will be discussed in late January, and you need to propose and communicate your project idea in early February (3 points). You will choose team leader, communicator, engineer (optional), software engineer (optional). Your team will be provided with one basic Arduino kit, additional sensors can be provided as well. In the next step in February-March, you will work with your classmates as a team to use this Arduino kits to build more elaborate physical measurement design to perform an experiment of your choice. Group project ideas (with details) will be submitted on OWL in early March (3 points). Each group will have final project presentation on March 27, 2024 (4 points).

Lab notebook: All students are required to keep a record of their work in laboratory notebooks using **<u>pens</u>**. Your notebooks will be checked and **marked** twice during the term during your lab experiments.

Final exam (3 hours) will be similar to open-book tests, covering the entire course, including lab visits.

Student Absences

If you are unable to meet a course requirement due to illness or other serious circumstances, please follow the procedures below.

Assessments worth less than 10% of the overall course grade:

1. If you miss one of the in-class tests, you can submit it in Assignment mode on OWL (see pages 1-2).

2. If you miss laboratory experiment, make-up lab periods are planned. See page 6 for details.

Absences from Final Examinations

If you miss the Final Exam, please contact the Academic Counselling office of your Faculty of Registration as soon as you are able to do so. They will assess your eligibility to write the Special Examination (the name given by the University to a makeup Final Exam).

You may also be eligible to write the Special Exam if you are in a "Multiple Exam Situation" (e.g., more than 2 exams in 23-hour period, more than 3 exams in a 47-hour period).

Cheating

University policy states that cheating is a scholastic offence. The commission of a scholastic offence is attended by academic penalty, which may include expulsion from the program. If you are caught cheating, there will be no second warning. Cheating includes having available any other electronic devices than a watch and a calculator during a test or exam. You may not have a cell phone accessible, even to use it as a calculator or watch. Complete information on the University policy on academic offenses can be found at
http://www.uwo.ca/univsec/handbook/appeals/scholastic_discipline_undergrad.pdf

Plagiarism

Students must write their lab reports, tests and final exam in their own words. Whenever students take an idea, or a passage from another author, they must acknowledge their debt both by using quotation marks where appropriate and by proper referencing such as footnotes or citations. Plagiarism is a major academic offence (see Scholastic Offence Policy in the Western Academic Calendar).

All required papers may be subject to submission for textual similarity review to the commercial plagiarism detection software under license to the University for the detection of plagiarism. All papers submitted for such checking will be included as source documents in the reference database for the purpose of detecting plagiarism of papers subsequently submitted to the system. Use of the service is subject to the licensing agreement, currently between The University of Western Ontario and Turnitin.com (http://www.turnitin.com).

Religious Accommodation

When a course requirement conflicts with a religious holiday that requires an absence from the University or prohibits certain activities, students should request accommodation for their absence in writing at least two weeks prior to the holiday to the course instructor and/or the Academic Counselling office of their Faculty of Registration. Please consult University's list of recognized religious holidays (updated annually) at
https://multiculturalcalendar.com/ecal/index.php?s=c-univwo

Accommodation Policies

Students with disabilities are encouraged to contact Accessible Education, which provides recommendations for accommodation based on medical documentation or psychological and cognitive testing. The policy on Academic Accommodation for Students with Disabilities can be found at: https://www.uwo.ca/univsec/pdf/academic_policies/appeals/Academic Accommodation_disabilities.pdf

Support Services

The simplest way to contact us outside of lectures is via your UWO e-mail account. Please allow 3–5 working days for a response. We will not **read or respond** to emails from addresses that do not end in "@uwo.ca" and they may be treated by the Western University servers as spam.

Please visit the Science & Basic Medical Sciences Academic Counselling webpage for information on adding/dropping courses, academic considerations for absences, appeals, exam conflicts, and many other academic related matters: https://www.uwo.ca/sci/counselling/.

Students who are in emotional/mental distress should refer to Mental Health@Western (https://uwo.ca/health/) for a complete list of options about how to obtain help.

Western is committed to reducing incidents of gender-based and sexual violence and providing compassionate support to anyone who has gone through these traumatic events. If you have experienced sexual or gender-based violence (either recently or in the past), you will find information about support services for survivors, including emergency contacts at https://www.uwo.ca/health/student_support/survivor_support/get-help.html
To connect with a case manager or set up an appointment, please contact support@uwo.ca.

The Department of Physics and Astronomy may, in exceptional circumstances, adjust the final course marks in order to conform to Departmental policy."

This course is supported by the **Science Student Donation Fund**. If you are a BSc or BMSc student registered in the Faculty of Science or Schulich School of Medicine and Dentistry, you pay the Science Student Donation Fee. This fee contributes to the Science Student Donation Fund, which is administered by the Science Students' Council (SSC). One or more grants from the Fund have allowed for the purchase of equipment integral to teaching this course. You may opt out of the Fee by the end of September of each academic year by completing the online form linked from the Faculty of Science's Academic Counselling site. For further information on the process of awarding grants from the Fund or how these grants have benefitted undergraduate education in this course, consult the Chair of the Department or email the Science Students' Council at ssc@uwo.ca.

Appendix I

Week 1	Jan 8 **Lecture** Introduction	Jan 9 **Lecture** Error and uncertainty. Statistical analysis of data (see notes on OWL)	Jan 10 **Lecture** Error and uncertainty. Using Excel (see notes on OWL)
Week 2	Jan 15 **Lab 1 instructions** Oscilloscope, function generators (Lab manual, OWL) Waves and signals (Chapter 6*)	Jan 16 **Lecture** Linear circuits in DC (Chapters 2 and 3*)	Jan 17 **Lecture** How to write a lab report Linear circuits in DC.
Week 3	Jan 22 **Lab 2 instructions** Resistive-capacitive (RC) circuits (Lab manual, OWL) Transient RC/RL circuits (Ch. 7)	Jan 23 **Lecture** DC equivalent circuits & network theorems (Ch. 4)	Jan 24 **Test 1** Error, uncertainty, Linear DC circuits (OWL notes, Ch. 2-3)
Week 4	Jan 29 **Lab 3 instructions** RLC filters (Lab manual, OWL) ***Lab 1&2 reports are due***	Jan 30 **Lecture** DC equivalent circuits & network theorems (Ch. 4)	Jan 31 ***Team projects. Day 1***. *Introduction to Arduino* *Additional resources*
Week 5	Feb 5 **Lab 4 instructions** Radioactive decay (Lab manual, OWL)	Feb 6 **Lecture** DC equivalent circuits & network theorems (Ch. 4)	Feb 7 **Test 2** Network theorems (OWL notes, Ch. 4), Labs 1 and 2 Transient RC/RL circuits (Ch. 6-7).
Week 6	Feb 12 **Lecture** Operational amplifiers (Ch. 5)	Feb 13 **Lecture** Operational amplifiers (Ch. 5)	Feb 14 Lab reports -reminders ***Team building exercise***
Week 7	Feb. 17–25 - Family Day (19) and Spring Reading Week (Saturday – following Sunday) No classes		
Week 8	Feb 26 **Lab 5 instructions** Solar cell efficiency (Lab manual, OWL) ***Lab 3&4 reports are due***	Feb 27 **Lecture** Semiconductors and transistors (see notes on OWL)	Feb 28 **Lecture** Semiconductors and transistors (see notes on OWL)
Week 9	Mar 4 **Lab 6 instructions.** Digital logic. (Lab manual, OWL)	Mar 5 **Lecture.** AC circuit complex analysis (Chapter 8)	Mar 6 **Test 3** Operational amplifiers, Semiconductors and transistors. Lab#3 and 4
Week 10	Mar 11 **Lab 7 instructions.** Helmholtz coils (Lab manual) ***Lab 5&6 reports are due***	Mar 12 **Lecture** AC circuit complex analysis (Chapter 8), AC Power (Ch. 10)	Mar 13 **Lecture** Solar cell lecture and tour (TBC) ***Team projects detailed ideas due***
Week 11	Mar 18 **Lecture.** AC circuit complex analysis (Chapter 8) **Team projects week (no labs)**	Mar 19 **Lecture** Transformers	Mar 20 **Test 4** AC circuits.
Week 12	Mar 25 **Lecture** Three-phase circuit	Mar 26 Delta/Wye connected loads	Mar 27 ***Team projects presentations***
Week 13	Apr 1 **Lecture** Three-phase circuit, Delta/Wye connected loads ***Lab 7 reports are due***	Apr 2 Physics Machine shop (TBC)	Apr 3 **Lecture** 3-phase circuit, Delta/Wye connected loads
Week 14	Apr. 8 **Final exam review** ***All outstanding reports are due***	Apr 9-10: No classes	

*Chapters refer to the book of M. Nahvi, J.A. Edminister, Basic circuit analysis (4th ed.), Schaum's Outline Series, McGraw-Hill, New York, 2011 – ISBN: 978- 0-07-142582-9.

Appendix II
Lab schedule

Experiment	Section 002 Mon 3:30-6:30pm	Section 003 Tue 2:30-5:30pm	Section 004 Wed 2:30-5:30pm	Section 005 Thu 12:30-3:30pm	Lab report** due for ALL sections
1. Oscilloscope (S*)	Jan 15	Jan 16	Jan 17	Jan 18	Jan 29 (Mon) 11:55pm
2. Resistive-capacitive (RC) circuits (L*)	Jan 22	Jan 23	Jan 24	Jan 25	Jan 29 (Mon) 11:55pm
3. Resistive-Inductive-Capacitive (RLC) filters (S)	Jan 29	Jan 30	Jan 31	Feb 1	Feb 26 (Mon) 11:55pm
4. Statistics: Radioactive decay (L*)	Feb 5	Feb 6	Feb 7	Feb 8	Feb 26 (Mon) 11:55pm
Make-up week for labs #1-4	Feb 12	Feb 13	Feb 14	Feb 15	
Spring reading week	No labs				
5. Solar cell efficiency (L)	Feb 26	Feb 27	Feb 28	Feb 29	Mar 11 (Mon) 11:55pm
6. Digital logic (S)	Mar 4	Mar 5	Mar 6	Mar 7	Mar 11 (Mon) 11:55pm
7. Helmholtz coils (L)	Mar 11	Mar 12	Mar 13	Mar 14	Apr 1 (Mon) 11:55pm
8. Team projects	Mar 18	Mar 19	Mar 20	Mar 21	Mar 27 Presentation 9:30am-10:30am
Make-up week for labs #5-8	Mar 25	Mar 26	Mar 27	Mar 28	

* S – short report (Abstract, result figures and summary); L – long report

** To be uploaded to OWL in one of the following formats: PDF (preferred) or Word (*.doc, *.docx).

All of the reports need to be uploaded to OWL by April 8, 2024, 11:55pm

Policy for make-up weeks

- Make-up weeks are designed to repeat experiments that did not work in the first place. They are not intended for you to start experiments from scratch or replace lab activities that must take place during the week in which the experiment is planned. With the exception of medical or other documented issues, students will **not** be allowed access to the lab during make-up weeks if they were absent from the lab during the week in which the experiments were originally planned and did not try them at that time. Teaching assistants will record attendance of students during regular lab hours.

  If you cannot attend labs in person so any legitimate reason, please email Dr. Goncharova (lgonchar@uwo.ca) as soon as possible with the following information:

  (a) explain your reasons;

  (b) provide information about your section number and TA name.

  During make-up weeks, only a few setups for each experiment are available. Students will be allowed to access the equipment on a first-come-first serve basis

Physics 2910G - Introduction to Physical Measurement
Learning outcomes

Students will be able to…

Error analysis and presentation of uncertainties
- Calculate experimental uncertainties from analog and digital meters (instruments)
- Find different errors associated with laboratory measurements to be able to explain if experimental results are significantly different from calculated or theoretically predicted values
- Apply error propagation rules to find total uncertainty in reported experimental result
- Define normal (Gaussian) distribution and show how it is different from Poisson distribution
- Apply Chauvenet's criterion to reject suspicious experimental results

Circuit analysis
- Apply Kirchhoff's voltage and current laws for linear DC and AC circuits
- Calculate equivalent resistance (capacitances, inductors) from circuits with resistors (capacitances, inductors) connected in series or parallel
- Apply mesh current method, network superposition and reduction methods in circuit analysis
- Construct Thevenin and Norton equivalent circuits to simplify DC/AC circuit calculations
- Express behavior of transient first-order circuits in terms of time-dependent functions

Operational amplifier (op amp) circuits
- Differentiate input and output connections of the operational amplifiers, and the feedback resistor to calculate op amp gain
- Apply Kirchhoff's current law at the input terminals in op amp analysis cases, such as inverting and noninverting circuits, voltage follower, differentiator and integrator circuit
- Practice working with op amps in the amplitude modulation circuit lab

Semiconductor devices and solar cells
- Define materials (metals, semiconductors and insulators) by the difference in the band gap and remember few examples and band gap values for each type of material
- Explain the difference between intrinsic and doped semiconductors (p- and n-types) and formation of depletion layer and barrier layer in p-n junctions
- Draw a schematic band diagram of solar cell to explain the motion of carriers under illumination
- Create solar cell equivalent circuit diagram with resistance in series and shunt resistance in order to measure current voltage curves and calculate experimental power generated by the solar cell

Three-phase circuits
- Transform Δ-shaped bridge circuits to Y circuits and back. Apply phase (vector) diagrams for balanced Y-Y and Δ-Δ three phase generator-load connections to be able to find currents, voltages and powers
- Apply Faradey's law to explain the electrical generator performance

Laboratory and writing skills
- Effectively use oscilloscope, electrical breadboards, function generators, power supplies, multimeters in circuit analysis. Construct low- and high-pass filters on breadboards and calculate their characteristic
- Practice writing laboratory notes with proper scientific notations and uncertainties
- Apply Gaussian and Poisson distributions to nuclear decay processes data
- Calculate experimental and theoretical power characteristics of solar cells and electrical filter

Last updates: December 20, 2023