Physics 2910G - Introduction to Physical Measurement

Winter 2021, v. 01/12/2021

Lectures: Mon, Wed, Fri 9:30am – 10:30am, via Zoom

Laboratories:
Sec. 002 Monday, 3:30pm - 6:30pm
Sec. 003 Tuesday, 2:30pm - 5:30pm
Sec. 004 Wednesday, 2:30pm - 5:30pm
Sec. 005 Thursday, 12:30pm - 3:30pm
Maximum 6 students per day, in Room PAB 126

Prerequisites: a minimum mark of 60% in Physics 1020 or 1024, or 1026, or the former 025, or a minimum average of 80% in Physics 1028A/B and 1029A/B; and a minimum mark of 60% in each of (Calculus 1000A/B or 1100A/B) and (Calculus 1301A/B or 1501A/B), or in Applied Math 1413.
Corequisite(s): Physics 2101A/B and 2102A/B or the former Physics 200.

Instructor: Professor Lyudmila Goncharova
Office hours: via Zoom, 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. P. Horowitz, W. Hill, The art of electronics (3rd ed.), Cambridge University Press, New York, 2015 – ISBN 978-0-521-80926-9.
2. J.R. Taylor, An introduction to error analysis (2nd ed.), University Science books, Sausalito, 1997 – ISBN 0-935702-75-X.
3. J. O'Malley, Basic circuit analysis (2nd ed.), Schaum's Outline Series, McGraw-Hill, New York, 2011 – ISBN: 978-0-07-175643-3.

Other support material will be uploaded to the course website**.**
Lab notebook (hardcover or electronic): you will need to submit electronic copy of the few lab notebook pages on OWL as PDF files.

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

Evaluation:

Tests/assignments (sum of all test marks, max 20%, see details below)	**20 %**
Laboratory reports, pre-labs and lab book	**40+4+4=48 %**
Arduino projects and group project presentations	**10 %**
Final assignment	**22 %**

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) "Fast mode": The student completes the open-book test in 3 hours and submits it by 12:30 pm during the day when the test starts. **Max: 5.0% per test**
(b) "Slow mode": The student completes the test and uploads it to OWL electronically by Friday, 9:20 am. **Max: 3.0% per test**
Please convert all pages into a SINGLE PDF file and upload this single file on OWL.

Laboratory reports
All lab reports must be uploaded to the OWL website must be satisfactorily completed in order to pass the course. There will be NOT additional make-up time provided in Winter 2021, talk to your TA and instructor if you cannot complete experiment at the assigned da. See Appendix II and related make-up policy.
Pre-lab component (1 point for each lab, 4 in total) 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 checked by your TA.
Lab notebooks (4 points)**:** all students are required to keep a record of their work in laboratory notebooks, hardcopy or electronic files. Your notebooks will be checked and marked twice (preliminary and final marking) during the term. You will be asked to upload copy of your lab notebook notes on OWL.
Laboratory reports are due at the dates listed in Appendix II. There will be 4 long (10 % each) reports. Late reports will be accepted with **penalties**:
(a) Your report mark will be reduced by 10% *right after deadline*: with maximum of 9.0% for long reports.
(b) Very late report marks will be divided by 2 in two weeks after the deadline (5.0% maximum).
All four reports need to be uploaded to OWL by April 2, 2021 11:55pm in order to pass the course and no lab reports will be accepted after that date without special permission.

Arduino projects and group project presentations (4+3+3=10 points).
This year we will be learning how to use Arduino kits to performing basic measurements at home during lecture time in January-February. You will be provided with Arduino kits (distribution protocol will be provided to you by January 25th). Several lecture time slots will be dedicated to introduction to Arduino kits, programming language and doing simple projects. In the next step in mid-February, you will also 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. Preliminary project ideas will be submitted on OWL in late February. Each group will have final project presentation on March 26, 2021.

Final exam assignment (3+ hours) will be similar to open-book tests, covering the entire course, including lab material and guest lectures.

Accommodation and Accessibility
If you are unable to meet a course requirement due to illness or other serious circumstances, you must seek approval for the absence as soon as possible. Approval can be granted either through a self-reporting of absence or via the Dean's Office/Academic Counselling unit of your Home Faculty. If you are a Science student, the Academic Counselling Office of the Faculty of Science is located in NCB 280, and can be contacted at scibmsac@uwo.ca.

If you miss on of the in-class tests due to illness or other serious circumstances, you can take test as a home assignment. If you miss the Final Exam, please contact your faculty's Academic Counselling Office as soon as you are able to do so. They will assess your eligibility to write the Special Exam (the name given by the university to a makeup Final Exam).

For further information, please consult the university's policy on academic consideration for student absences: https://www.uwo.ca/univsec/pdf/academic_policies/appeals/Academic_Consideration_for_absences.pdf.

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 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).

Classroom Conduct

Disruptive behaviour will not be tolerated in class. Please respect the rights of your classmates to benefit from the lecture by limiting your conversations to those essential to the class. Students who persist in loud or rude behaviour will be asked to leave.

Accessibility

Please contact the course instructor if you require lecture or printed material in an alternate format or if any other arrangements can make this course more accessible to you. You may also wish to contact Student Accessibility Services (SAS) at 661-2147 if you have any questions regarding accommodations. The policy on Accommodation for Students with Disabilities can be found here: https://www.uwo.ca/univsec/pdf/academic_policies/appeals/Academic%20Accommodation_disabilities.pdf
The policy on Accommodation for Religious Holidays can be found here:
http://www.uwo.ca/univsec/pdf/academic_policies/appeals/accommodation_religious.pdf

Help

Students who are in emotional/mental distress should refer to Mental Health@Western (http://www.health.uwo.ca/mental_health) for a complete list of options about how to obtain help. Additional student-run support services are offered by the USC, http://westernusc.ca/services..

Contacting Us

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.

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

Appendix I

Course schedule**: all activities in this schedule** will be on-line, via ZOOM).

	Monday (9:30-10:30am)	Wednesday (9:30-10:30am)	Friday (9:30-10:30am)
Week 1	Jan 11 Introduction	Jan 13 Errors and uncertainties, statistical analysis of the data (notes on OWL)	Jan 15 Errors and uncertainties (notes on OWL)
Week 2	Jan 18 **Lab 1 instructions** Oscilloscope, function generators, bread boards (Lab manual, OWL)	Jan 20 Linear DC circuits	Jan 22 Linear DC circuits
Week 3	Jan 25 Resistive-capacitive (RC) circuits Writing lab report	Jan 27 **Test 1.** Experimental uncertainties, Linear DC circuits	Jan 29 Arduino day 1
Week 4	Feb 1 **Lab 2 instructions** RC and RLC filters (Lab manual, OWL) ***Lab 1 drafts are due***	Feb 3	Feb 5 Arduino day 2 How to write a lab report (2)
Week 5	Feb 8 RC and RLC filters ***Lab 1 reports are due***	Feb 10 **Test 2.** Operational amplifiers.	Feb 12 Arduino day 3 ***Team building exercise***
Week 6	Feb 15 Spring reading week - No classes		
Week 7	Feb 22 **Lab 3 instructions.** Statistics, Radioactive decay (Lab manual, OWL) ***Lab 2 report is due***	Feb 24 Network theorems (DC and AC)	Feb 26 Network theorems (DC and AC)
Week 8	Mar 1 Network theorems (DC and AC)	Mar 3 **Test 3.** Network theorems (DC and AC), Statistics	Mar 5 Arduino day 4 ***Team projects prelim ideas due***
Week 9	Mar 8 **Lab 4 instructions.** Solar cell efficiency ***Lab 3 report is due***	Mar 10 Semiconductors	Mar 12
Week 10	Mar 15 Three-phase circuits	Mar 17 **Test 4.** Semiconductors	Mar 19
Week 11	Mar 22	Mar 24	Mar 26 ***Arduino projects presentations***
Week 12	Mar 29 ***Lab 4 report is due***	Mar 31 **Final assignment review**	Apr 2 ***All outstanding lab reports are due***
Week 13	Apr 5 **Final assignment review**		

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Appendix II Winter 2021, v. 01/12/2021
Lab schedule (ZOOM, possible

Experiment	Subgroup*	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. Soundcard Oscilloscope (ZOOM)	1/2	Jan 18	Jan 19	Jan 20	Jan 21	Feb 1 (drafts), Feb 8 (final) (Mon) 11:55pm
Collect Arduino kits in PAB building (entrance)	1/2	Jan 25	Jan 26	Jan 27	Jan 28	
2. RC/RLC filters (ZOOM)	1/2	Feb 1	Feb 2	Feb 3	Feb 4	Feb 22 (Mon) 11:55pm
	Makeup	Feb 8	Feb 9	Feb 10	Feb 11	
Spring reading week		Week of Feb 15: No labs				
3. Statistics: Radioactive decay	1	Feb 22	Feb 23	Feb 24	Feb 25	Mar 8 (Mon) 11:55pm
	2	Mar 1	Mar 2	Mar 3	Mar 4	
4. Solar cell efficiency	2	Mar 8	Mar 9	Mar 10	Mar 11	Mar 29 (Mon) 11:55pm
	1	Mar 15	Mar 16	Mar 17	Mar 18	
*Arduino Project****	1/2	Mar 22	Mar 23	Mar 24	Mar 25	

* Students lists for each stream (subgroup) will be posted in early January, 2021.
**Lab report, to be uploaded to OWL in one of the following formats: PDF (preferred) or Word (*.doc, *.docx).

Last day to deliver <u>all</u> lab reports in order to pass the course: April 2, 2021 11:55pm

*** Use this time to finish your group projects on Zoom

Policy for make-up weeks

If you cannot attend lab (2-4) in person so any legitimate reason, please email Dr. Goncharova as soon as possible with the following information:

(a) explain your reason;

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

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