# PHYS4311 Syllabus

## Course Description and Prerequisites

The course, Laboratory Physics (PHYS4311), is for those who plan to enhance their instrumentation skills and get experience as close as possible to real-life research. This course is structured through reading, doing and observing, team work and problem-solving, with little lecturing. We will spend 6 weeks on basic instruments both in mechanics and in electromagnetic, and on a research project. The second 6 weeks will be spent on signal transmission and generation (sensors) that feed the instruments, and on another research project. These two projects are different from the labs in the sense that students will have to come up with solutions and design the experiment for the observations and measurements. There will be no lab manuals to follow in this case. We will spend the last 2 weeks to do a real measurement of the lifetime of a particle that is all around us: the cosmic muons. Muon is a fundamental particle, the cousin of electron which, with nuclei, makes up atoms and all the chemical elements and compounds and eventually matter in the world. Muon, on the other hand, is not stable. It decays to an electron plus two other particles called neutrinos. Although all of these are in the range of upper graduate course level and in a very special field called particle physics or high energy physics, we will be using an instrument that was developed by SMU faculty to measure the lifetime of muon, an endeavor in real research.

Training and skills obtained in PHYS1105 and PHYS1106 will be needed in this course. Knowledge of basic data analysis will help understand the observation. On top of these, the prerequisites also include the knowledge of undergraduate physics plus adequate math capability.

This study will be guided by professor Jingbo Ye (office in Fondren Science Building 037, email yejb@smu.edu). The class will be divided into two groups. Each group will meet in two afternoons of the week. The actual time will be discussed when enrollment is complete.

## Learning objectives and textbook

**Learning outcomes**

At the conclusion of this lab course, a devoting student will receive training on basic instruments with data acquisition software in both Mechanical and Electrical measurements. The student will understand signal generation and transmission, with experience in constructing a real detector using a plastic scintillator. The training will complete with a real physics experiment to measure the decay lifetime of a fundamental particle muon (the second generation of leptons). The student will also learn how to research for information that is not provided in the lab manual, to analyze and present (with plots and

tables) observation and measurement, and finally to write the report in a scientific way.

**Textbook** The lab manual will be provided to students.

**Course Format and Information**

This is guided study. Students will read the lab manual and understand the requirements before coming to the lab. After discussion with the instructor and a thorough understanding of the problem in the lab, the students set out to perform the measurements, and discuss with the instructor about issues in the experiments and about the observations. The students will then turn in the lab report to earn the grade at the end of each lab.

**Class attendance is required**. Lab make-up within the same week can be arranged. Once the instruments are removed, no lab make-up will be allowed.

**Grading policy:** Final grades will be the simple average of the grades of each lab report, including the two lab projects. There will be no written tests and exams in this course. The Numerical grade and letter grade conversion is based on:

| Letter | A | A- | B+ | B | B- | C+ | C | C- | D+ | D | D- | F |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Numerical (%) | 90.0 | 85.0 | 80.0 | 75.0 | 70.0 | 66.6 | 63.3 | 60.0 | 56.6 | 53.3 | 50.0 | |

**Other policies:**

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| **Disability Accommodations** | Students needing academic accommodations for a disability must first register with Disability Accommodations & Success Strategies (DASS). Students can call 214-768-1470 or visit http://www.smu.edu/Provost/ALEC/DASS to begin the process. Once registered, students should then schedule an appointment with the professor as early in the semester as possible, present a DASS Accommodation Letter, and make appropriate arrangements. Please note that accommodations are not retroactive and require advance notice to implement. |
| **Religious Observance** | Religiously observant students wishing to be absent on holidays that require missing class should notify their professors in writing at the beginning of the semester, and should discuss with them, in advance, acceptable ways of making up any work missed because of the absence. (See University Policy No. 1.9.) |
| **Excused Absences for University** | Students participating in an officially sanctioned, scheduled University extracurricular activity should be given the opportunity to make up class assignments or other graded |

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| **Extracurricular Activities** | assignments missed as a result of their participation. It is the responsibility of the student to make arrangements with the instructor prior to any missed scheduled examination or other missed assignment for making up the work. (University Undergraduate Catalogue) |

**Schedule**:

| Week | Lab | Notes |
|---|---|---|
| **1 (1/25–29)** | Time measurements (second to nano seconds); Mass measurements (kilogram, gram, to atoms). | |
| **2** | Length measurements (meter to nano meters); Coordinate measurements by GPS, lab project 1. | The lab project is due in week 6. |
| **3** | What a digital multimeter can do? | |
| **4** | Oscilloscope, quantity (voltage) that changes with time; and a signal generator. | |
| **5** | Mapping the magnetic field of a magnet. | |
| **6** | A review of Capstone and SPARKvue; a survey of contempnary DAQ hardware and software; Control the scope through my PC. | |
| **7** | Understand single transmission and integrity in a cable; transmission attenuation and connection reflection; impedance match. | Assign the lab project 2: pixel CMOS sensor. |
| **8** | Signal transmission speeds in cable, in optical fiber, and in air. | |
| **9** | Light (photon) sensors and their applications. | |
| **10** | Making a particle detector: part 1, the plastic scintillator | |
| **11** | Making a particle detector: part 2, the PMT (photon multiplier tube). A discussion of SiPM (Silicon Photon Multiplier). | |
| **12** | Class presentations on project 1 and 2. | |
| **13** | The muon lifetime measurement | |
| **14 (4/26–30)** | The muon lifetime measurement | |
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