Introduction and Course Description

SYLLABUS FOR PHYSICS 163 – Introduction to particle physics and ATLAS experiment of LHC at CERN (CLASS #: 76155, Course ID: 019751) Fall 2018 (TTH: 9:00am -- 10:15am, Notice: this is an ONLINE class. Lecture will be given on Zoom (http://fresnostate.zoom.us/). There will be no classroom for this online class and students can participate from anywhere with access to internet)	
Fall 2018	California State University, Fresno
Course ID: 019751; Class #: 76155	Instructor: Dr. Yongsheng Gao
Units: 3	Office: McLane Hall Room 175 A/B
Time: TTH: 9:00am – 10:15am	E-Mail: yogao@csufresno.edu
Location: Online class, No classroom	Telephone: 559-278-4554
Website: All course information can be found at http://www.fresnostate.edu/academics/blackboard/	Office Hours: TTH 8am to 9am and by appointment

Prerequisites

For Fresno State students, PHYS 4A (Mechanics) and 4B (Electromagnetism) are required. PHYS 4C (modern physics) and 102 (Modern physics) are **strongly recommended** as this course will start with special relativity and relativistic kinematics. Because we can only spend about two weeks on this important topic which is the basis of particle physics, students will have a very hard time with the exams if they don't have good knowledge of special relativity and relativistic kinematics in advance. **Student from other CSU Nuclear and Particle Physics Consortium (NUPAC) campuses must get approval from his/her department and the liaison faculty of that campus that he/she meets the prerequisites requirement to take this class.**

Web Site and Course Information: All course information can be found in http://www.fresnostate.edu/academics/blackboard/ for students from CSU Fresno (Fresno State). For students taking this course from other CSU NUPAC campuses, they will have access to Fresno State Blackboard through their guest accounts after they enroll to this course. **For students not from Fresno State who'd like to take this course, the liaison faculty on your campus will need to email your name and email address to Dr. Yongsheng Gao at Fresno**

State before your enrollment can be approved by the Fresno State registrar's office. Information about CSU NUPAC and liaison faculty at NUPAC campuses can be found at http://zimmer.csufresno.edu/~yogao/ATLAS/.

Important Enrollment information for students not from CSU Fresno:

The CSU Fully Online enrollment dates from the CSU Chancellor's Office for CSU campuses for Fall 2018 are listed below. Please note that some campuses cut off registration BEFORE the start of instruction at their campuses. Therefore, it is very important that students enroll during the allowed enrollment windows at their campuses (in fall of 2016, about half of the students interested in taking this class couldn't enroll because they missed the enrollment windows). Please check with the registrar of your campus if you have any questions.

Fall 2018 CSU Fully Online Courses - Enrollment Dates				
Campus	**Term Type**	**AB386 Enrollment Dates**	**CourseMatch Enrollment Dates**	**Course Start Date**
Bakersfield	Semester	June 1 - September 5	June 1 - September 5	8/27/2018
Channel Islands	Semester	August 6 - August 24		8/27/2018
Chico	Semester	August 13 - August 31		8/27/2018
Dominguez Hills	Semester	August 13 - August 24		8/27/2018
East Bay	Semester	June 1 - August 10	June 1 - August 10	8/20/2018
Fresno	Semester	August 6 - September 5		8/23/2018
Fullerton	Semester	August 18 - August-25	June 1 - August 25	8/25/2018
Humboldt	Semester	August 6 - August 17		8/17/2018
Long Beach	Semester	June 1 - September 10		8/20/2018
Los Angeles	Semester	August 6 - August 19		8/20/2018
Monterey Bay	Semester	August 20 - September 3		8/27/2018
Northridge	Semester	August 17 - August 31		8/25/2018
Pomona	Semester	August 13 - September 6		8/20/2018
Sacramento	Semester	August 14 - August 24	June 1 - August 24	8/27/2018
San Diego	Semester	August 17 - August 26		8/27/2018
San Francisco	Semester	August 11 - August 26	June 1 - August 26	8/27/2018
San Jose	Semester	August 8 - August 15	June 1 - August 10	8/21/2018
San Marcos	Semester	August 21 - September 7	June 1 - August 27	8/27/2018
Sonoma	Semester	August 15 - August 31		8/20/2018
Stanislaus	Semester	June 1 - August 16		8/22/2018

Required Textbooks and Materials

Textbook/Reference: Donald H. Perkins, ***Introduction to High Energy Physics***
(4th Edition) Cambridge University Press, ISBN: 0-521-62196-8

Examinations and Major Assignments

There will be one midterm exam (75 mins, closed book with formula sheet provided) and one final exam (120 mins, accumulative, closed book with formula sheet provided). There will be also homework assignments and one term paper.

Study Expectations:

It is expected that students will spend at least 2 hours of study time outside of class for every one hour in class. Since this is a 3-unit class, you should expect to study at least **5** hours outside of class each week. Some students may need more outside study time and some less.

For free tutoring on campus, contact the Learning Center (http://www.fresnostate.edu/studentaffairs/lrc/) in the Collection Level (basement level) of the Henry Madden Library. You can reach them by phone at 278-3052.

"Our campus has developed SupportNet (http://www.fresnostate.edu/studentaffairs/supportnet/) to connect students with specific campus resources promoting academic success. I have agreed to participate in this program and may refer you to it if I believe you need the services provided by SupportNet to succeed in this course."

Grading

POSSIBLE POINTS: 30% HW
50% Exam (Midterm: 20%, Final: 30%)
20% Term Paper

HOMEWORK POLICY: UNEXCUSED LATE HW WILL NOT BE ACCEPTED.

The total score required for a given letter grade does not depend on the performance of the remainder of the class. It depends only on an analysis of the difficulty of the examination questions, your performance, and how hard you put an effort in this course.

Approximate grading scale: 90% – 100% A
75% – 89.9% B
60% – 74.9% C
50% – 59.9% D

Attendance is not mandatory. If you are absent from class, it is your responsibility to check on announcements made while you were away.

Incomplete Grade: The "I" grade is given **only** when a student fails to complete a portion of the required course work and when he/she has completed at least 2/3 of the required work at a **passing** level.
When completing an I, the student does only the unfinished work.
The instructor will strongly enforce this university policy.

Course Goals and Primary Learning Outcomes

Course Goals:

The course will provide an introduction to particle physics and the ATLAS (A Toroidal LHC ApparatuS) experiment of the Large Hadron Collider (LHC) at the European Organization for Nuclear Research (CERN) near Geneva, Switzerland. This course is intended for advanced undergraduate students or beginning graduate students, especially those who are interested in working at CERN or other ATLAS sites on ATLAS research projects during summer with the CSU ATLAS program. It will cover relativistic kinematics, the elementary particles and ideas underlying the Standard Model of particle physics, interaction of particles with matter, basic detector technology and experimental methods in particle physics, especially the ATLAS experiment of the LHC at CERN. The students who are interested in working at CERN or other ATLAS site with the CSU ATLAS program during summer are required to take this course before they can work at CERN or other ATLAS sites. This course is offered every fall semester to prepare new CSU students to work at CERN on ATLAS research every summer.

ATLAS collaboration consists of ~3000 physicists from ~220 institutions of 40 countries all over the world. Among them are ~500 US physicists from ~50 US national labs and universities. They include 4 US national labs (Argonne National Lab, Brookhaven National Lab, Lawrence Berkeley National Lab, and Stanford Linear Accelerator Center (SLAC)), and ~45 US universities (Harvard, Yale, MIT, Columbia, Stanford, U. of Chicago, UC-Berkeley, Michigan, Stanford, UPenn, UT-Austin, Washington, Wisconsin, etc.). Fresno State joined ATLAS experiment in 2007 and our ATLAS faculty, postdoctoral researchers and students enjoy the same privilege on ATLAS and CERN as those from top research institutions. Among all the 23 CSU campuses, Fresno State was the only one on ATLAS or CMS, the two LHC experiments designed to search for new physics beyond current known physics framework. ATLAS and CMS experiments discovered the Higgs boson (so-called “God” particle) on 7/4/2012 which made headline news in all major news media all over the world. The Higgs discovery was named by Science magazine as the 2012 “Breakthrough of the Year” and resulted in the award of the 2013 Nobel Physics Prize to the Higgs theory. Fresno State was the only CSU campus involved in the Higgs discovery. This is also the first research a CSU is involved in which has resulted in a Nobel Prize.

To provide the outstanding ATLAS/CERN experience to a wider CSU community, we have been building up the CSU Nuclear and Particle Physics Consortium (NUPAC). CSU NUPAC already consists of 17 CSU campuses (Bakersfield, Channel Islands, Chico, Dominguez Hills, East Bay, Fresno, Humboldt, Long Beach, Los Angeles, Northridge, Cal Poly Pomona, Sacramento, San Bernardino, San Francisco, Cal Poly San Luis Obispo, Sonoma, and Stanislaus). In summer of 2015 with approval from CERN and ATLAS, the institution name of our ATLAS program at

CERN was changed from “California State University, Fresno” to “California State University” with the joining of new ATLAS faculty Dr. Joshua Moss from CSU Sacramento in 2014. CSU East Bay hired new ATLAS faculty Kathryn Grimm in 2017 to contribute to CSU ATLAS and NUPAC. Fresno State and Dr. Yongsheng Gao remain the home institution and team leader with Dr. Joshua Moss and Dr. Kathryn Grimm as deputy team leaders of the new CSU ATLAS program. Every summer since 2008, we have been sending 5 to 12 students from CSU NUPAC campuses to work at CERN on ATLAS research projects. The following table shows the students from CSU NUPAC campuses worked at CERN on ATLAS research each summer since 2008.

Year	CSU NUPAC students worked at CERN on ATLAS research projects
2018	12 (Fresno: 3; Channel Islands: 2; Sacramento: 5; San Francisco: 1; Sonoma: 1)
2017	12 (Fresno: 4; Channel Islands: 1; Humboldt: 1; Northridge: 1; Sacramento: 3; San Francisco: 1; Sonoma: 1)
2016	12 (Fresno: 6; Channel Islands: 1; Humboldt: 1; Los Angeles: 1; Sacramento: 2; Sonoma: 1)
2015	7 (Fresno: 5; Channel Islands: 2)
2014	7 (Fresno: 5; Channel Islands: 2)
2013	6 (Fresno: 3; Channel Islands: 3)
2012	5 (Fresno)
2011	6 (Fresno: 4; Pomona: 2)
2010	5 (Fresno: 2; Long Beach: 2; Sacramento: 1)
2009	5 (Fresno: 4; Sacramento: 1)
2008	5 (Fresno)

In August of 2015, Dr. Yongsheng Gao received a 3-year ~$250K grant from National Science Foundation (NSF) International Research Experience for Students (IRES) program. This IRES grant will support a total of 15 students from CSU NUPAC campuses to work at CERN for the incoming 3 summers (5 students every summer) from 2016 to 2018. The total cost for a student to travel and work at CERN for ~9 weeks is ~$6,000. The IRES award includes $5,000 for travel/housing/meal and $4,000 of stipend for each student to travel to and work at CERN during summer. The students are required to spend at least 8 full weeks at CERN working on ATLAS research projects. In addition, the students are strongly encouraged to spend another week or so visiting Europe after their work at CERN and before they return to the US. The 5 students selected to work at CERN with IRES award during summer of 2018 are: Rhiannan Ruef

(Channel Islands), Eric Goeken (Fresno), Christina Pino (Sacramento), Danielle Taylor (Sacramento), and Erik Castellanos-Vasquez. The 5 students selected to work at CERN with IRES award during summer of 2017 are: Brandon Gunn (San Francisco), Zachary Kurland (Sonoma), Annette Lopez (Fresno), Patrick Millin (Northridge), and Juan Solorio (Sacramento). The 5 IRES supported students during summer of 2016 are: Taylor Dinkins (Channel Islands), Michael Dobbs (Sonoma), Ian Guerrero (Humboldt), Olivia Krohn (Fresno), and Ethan Villarama (Los Angeles). The following table shows the 12 students working at CERN during summer of 2016 together with their mentors and research projects.

Student Name	CSU Campus	Mentor/Institution/Project
Aaron Bassill	Fresno	Christian Ohm (LBNL): SUSY
Taylor Dinkins	Channel Islands	Dan Guest (UC-Irvine): Event Display
Michael Dobbs	Sonoma	Lauren Tompkins (Stanford): B-tagging
Jimmy Gonzalez	Fresno	Andrew Nelson (UC-Irvine): New Physics/Dark Matter
Ian Guerrero	Humboldt	Fabio Cerutti (LBNL): Pixel detector
Sarah Kroeker	Fresno	Reina Camacho (Chicago): Trigger
Olivia Krohn	Fresno	Nikolina Ilic (Stanford): Higgs
Annette Lopez	Fresno	Daniel Whiteson (UC-Irvine): New Physics/Dark Matter
Haley Marez	Sacramento	Guido Volpi (INFN): FTK
Caleb Mosakowski	Sacramento	Jahred Adelman (NIU): Higgs
Fiona Pons	Fresno	Sam Meehan (Washington): Top Quark
Ethan Villarama	Los Angeles	Michael Kagan (SLAC): Heavy Higgs

This course will provide the required background knowledge for interested students to work on ATLAS research projects at CERN and other ATLAS sites. The students who are interested in applying for the IRES award are required to take this course. More information about applying to work at CERN can be found at this web site: http://zimmer.csufresno.edu/~yogao/ATLAS/ The students will need to learn the essential tools and skills (Linux, ROOT, C++, Python, etc.) before they work on ATLAS research at CERN**. The selected students to work at CERN or other ATLAS sites during summer of 2019 are required to take another Fresno State online class during spring of 2019 to learn these essential tools and skills to prepare for working at CERN. This online class (PHYS 175T) in spring of 2019 will be TTH 9:00am to 10:15am given by ATLAS faculty and postdoctoral researchers from Fresno State, Stanford, UC-Irvine, University of Washington, etc.**

Primary Learning Outcomes:

1) Students will learn and understand Special Relativity (Lorentz transformation for coordinates and velocity)
2) Students will understand relativistic kinematics (relativistic momentum, kinematic energy and total energy) and apply conservation of relativistic momentum and energy to collisions of particles
3) Students will discuss and analyze how various particles (electron, proton, neutron, muon, pion, neutrinos, strange particles, mesons and baryons containing heavy quarks, W, Z, Higgs, etc.) were discovered.
4) Students will learn and understand the Quark Model and the Standard Model of elementary particle physics
5) Students will identify and discuss the fundamental interactions (Electromagnetic, weak, strong and gravitational) and development of theories about these interactions
6) Students will discuss and analyze how particle accelerators work and basic design of various types of accelerators (e+e-, pp, ppbar, mu+mu-, etc.) and high energy physics experiments (fixed target, colliding beam)
7) Students will learn and understand the interactions of various particles with matter and their physics principles
8) Students will discuss and analyze the design and working principles of various particle detectors
9) Students will discuss and understand the European Organization for Nuclear Research (CERN), the Large Hadron Collider (LHC) at CERN and the various experiments at the LHC
10) Students will analyze and discuss the ATLAS experiment of LHC at CERN, sub-detectors of the ATLAS experiment and the Fresno State ATLAS program

Subject to Change Statement

This syllabus and schedule are subject to change in the event of extenuating circumstances. If you are absent from class, it is your responsibility to check on announcements made while you were absent.

University Policies

Students with Disabilities:

Upon identifying themselves to the instructor and the university, students with disabilities will receive reasonable accommodation for learning and evaluation. For more information, contact Services to Students with Disabilities in the Henry Madden Library, Room 1202 (278-2811).

Honor Code:

“Members of the Fresno State academic community adhere to principles of academic integrity and mutual respect while engaged in university work and related activities.” You should:

a) understand or seek clarification about expectations for academic integrity in this course (including no cheating, plagiarism and inappropriate collaboration)

b) neither give nor receive unauthorized aid on examinations or other course work that is used by the instructor as the basis of grading.

c) take responsibility to monitor academic dishonesty in any form and to report it to the instructor or other appropriate official for action.

Cheating and Plagiarism:

Cheating is the actual or attempted practice of fraudulent or deceptive acts for the purpose of improving one's grade or obtaining course credit; such acts also include assisting another student to do so. Typically, such acts occur in relation to examinations. However, it is the intent of this definition that the term 'cheating' not be limited to examination situations only, but that it include any and all actions by a student that are intended to gain an unearned academic advantage by fraudulent or deceptive means. Plagiarism is a specific form of cheating which consists of the misuse of the published and/or unpublished works of others by misrepresenting the material (i.e., their intellectual property) so used as one's own work." Penalties for cheating and plagiarism range from a 0 or F on a particular assignment, through an F for the course, to expulsion from the university. For more information on the University's policy regarding cheating and plagiarism, refer to the Class Schedule (Legal Notices on Cheating and Plagiarism) or the University Catalog (Policies and Regulations).

Computers:

"At California State University, Fresno, computers and communications links to remote resources are recognized as being integral to the education and research experience. Every student is required to have his/her own computer or have other personal access to a workstation (including a modem and a printer) with all the recommended software. The minimum and recommended standards for the workstations and software, which may vary by academic major, are updated periodically and are available from Information Technology Services or the University Bookstore (http://www.kennelbookstore.com). In the curriculum and class assignments, students are presumed to have 24-hour access to a computer workstation and the necessary communication links to the University's information resources."

Disruptive Classroom Behavior:

"The classroom is a special environment in which students and faculty come together to promote learning and growth. It is essential to this learning environment that respect for the rights of others seeking to learn, respect for the professionalism of the instructor, and the general goals of academic freedom are maintained. Differences of viewpoint or concerns should be expressed in

terms which are supportive of the learning process, creating an environment in which students and faculty may learn to reason with clarity and compassion, to share of themselves without losing their identities, and to develop an understanding of the community in which they live. Student conduct which disrupts the learning process shall not be tolerated and may lead to disciplinary action and/or removal from class."

Copyright Policy:

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Tentative Course Schedule

Fall 2018	**163 (Intro. to Particle Physics and ATLAS): Yongsheng Gao**
1: Aug 23 – Aug 24	Introduction, structure of atoms, building blocks of matter (Lecture 1)
2: Aug 27 – Aug 31	Natural units, Special Relativity (Lecture 2, 3)
3. Sep 4 – Sep 7	Relativistic kinematics and its applications in experimental high energy physics (Lecture 4, 5)

4: Sep 10 – Sep 14	Fundamental forces and discovery of elementary particles (Lecture 6, 7)
5: Sep 17 – Sep 21	Discovery of strange particles, the eightfold way (Lecture 8, 9)
6: Sep 24 – Sep 28	The Quark Model, November Revolution and its aftermath (Lecture 10, 11)
7: Oct 1 – Oct 5	The Quark Model, W and Z bosons, the Standard Model (Lecture 12, 13)
8: Oct 8 – Oct 12	Review and Midterm Exam
9: Oct 15 – Oct 19	QED, Feynman diagrams, QCD (Lecture 14, 15)
10: Oct 22 – Oct 26	Interactions of particles with matter, particle detectors (Lecture 16, 17)
11: Oct 29 – Nov 2	Interactions of particles with matter, particle detectors (Lecture 17, 18)
12: Nov 5 – Nov 9	Interactions of particles with matter, particle detectors (Lecture 19, 20)
13: Nov 13 – Nov 16	CERN, Large Hadron Collider (LHC) and ATLAS Experiment
14: Nov 19 – Nov 20	Thanksgiving Recess

15: Nov 26 – Nov 30	ATLAS Experiment of the LHC at CERN
16: Dec 3 – Dec 7	ATLAS Experiment of the LHC at CERN
17: Dec 10 – Dec 12	Review and Last Day of Instruction (12/12)