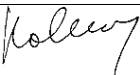
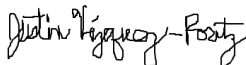


New York City College of Technology, CUNY  
CURRICULUM MODIFICATION PROPOSAL FORM

This form is used for all curriculum modification proposals. See the [Proposal Classification Chart](#) for information about what types of modifications are major or minor. Completed proposals should be emailed to the Curriculum Committee chair.

<b>Title of Proposal</b>	Changes to Applied Computational Physics: Academic Specializations
<b>Date</b>	September 8, 2023
<b>Major or Minor</b>	Major
<b>Proposers' Names</b>	V. Dorogan, G. Ossola, C. Welker
<b>Department</b>	Physics
<b>Date of Departmental Meeting in which proposal was approved</b>	September 7, 2023
<b>Department Chair Name</b>	Dr. Kolmakov
<b>Department Chair Signature and Date</b>	 11/15/2023
<b>Academic Dean Name</b>	Dr. Vazquez-Poritz
<b>Academic Dean Signature and Date</b>	 11/16/23
<b>Brief Description of Proposal</b> (Describe the modifications contained within this proposal in a succinct summary. More detailed content will be provided in the proposal body.)	This major Curriculum Change proposal targets the introduction of a Quantum Technology Specialization, a Computational Physics specialization, and an Astrophysics Specialization in the Applied Computational Physics program, in addition to improvements on general requirements. These changes are designed to improve the academic experience of all students and are built on the feedback that we have collected over the years from students and faculty, as well as the program assessment, on the current ACP curriculum.  <b>This proposal contains changes to X existing courses and Y new courses.</b>
<b>Brief Rationale for Proposal</b> (Provide a concise summary of why this proposed change is important to the department. More detailed content will be provided in the proposal body).	The present proposal for a Major Curriculum Change targets several aspects of the ACP program. The overarching goal of our proposal is to improve the experience for our students while increasing the enrollment in the program with the aim of ultimately providing more opportunities for our graduates in terms of paths to graduate studies as well as employment in the technological sector.
<b>Proposal History</b> (Please provide history of this proposal: is this a resubmission? An updated version? This may most easily be expressed as a list).	This is a new curriculum modification proposal.

Please include all appropriate documentation as indicated in the Curriculum Modification Checklist.

For each new course, please also complete the New Course Proposal and submit in this document.

Please submit this document as a single .doc or .rtf format. If some documents are unable to be converted to .doc, then please provide all documents archived into a single .zip file.

#### ALL PROPOSAL CHECK LIST

Completed CURRICULUM MODIFICATION FORM including:	
• Brief description of proposal	Ok
• Rationale for proposal	Ok
• Date of department meeting approving the modification	Ok
• Chair's Signature	Ok
• Dean's Signature	Ok
Evidence of consultation with affected departments List of the programs that use this course as required or elective, and courses that use this as a prerequisite.	Ok
Documentation of Advisory Commission views (if applicable).	N/A
Completed <a href="#">Chancellor's Report Form</a> .	Ok

#### EXISTING PROGRAM MODIFICATION PROPOSALS

Documentation indicating core curriculum requirements have been met for new programs/options or program changes.	n/a
Detailed rationale for each modification (this includes minor modifications)	Ok

## Rationale of the Proposal - Specializations in Applied Computational Physics

The Bachelor of Science in Applied Computational Physics (ACP) was opened for enrollment at City Tech in the Summer of 2017. As of the Summer of 2023, 19 students have graduated from the ACP Program.

Over past years, the Physics Department has collected information about the ACP program, stemming from conversations with students, feedback and comments from faculty members, assessment of program learning outcomes, experiences with employment after graduation and admission to graduate schools. While several aspects of our curriculum have proven to be well designed and led to successful experiences for our graduates, we have also identified several areas in which our program can and should be further improved.

In recent years, new technologies such as the applications of Quantum Devices have solidified and triggered a specific demand in the job market that the current academic offerings in the New York City area are not able to satisfy. The skill set of abilities and knowledge needed by these ventures heavily relies on Quantum Physics and related technologies, making it a perfect match for our Physics program at City Tech and a great opportunity for further expanding the degree offerings at City Tech.

Astrophysics is another field in which we have observed that academic opportunities for undergraduate students, within and outside CUNY, have been lacking. From conversation with our students, specifically the ones interested in continuing their studies in graduate school, we have witnessed a growing interest for a more focused program that could provide the strong foundations in physics, mathematics, and computational skills already provided by ACP, but also more advanced Astrophysics classes.

The present proposal for a Major Curriculum Change targets several aspects of the ACP program. The overarching goal of our proposal is to improve the experience for our students while increasing the enrollment in the program with the aim of ultimately providing more opportunities for our graduates in terms of paths to graduate studies as well as employment in the technological sector.

In particular, the present Curriculum Change proposal targets the following goals:

1. The introduction of a Quantum Technology Specialization in ACP: this Specialization will empower students with the ability of continuing their academic paths towards this interesting new frontier, as well as securing high quality employment in the private sector. The Specialization will effectively synergize with the Nanoscience Initiative of the ASRC and its Nanofabrication Facility. Three new courses have been specifically designed to support the Quantum Technology Specialization.
2. The introduction of an Astrophysics Specialization in ACP: this Specialization is designed for students that aim at continuing their studies in Graduate School. It is also an ideal path for students in search of a versatile skillset in computing, machine learning and physical modelling in preparation their career in the industry. The Specialization will effectively synergize with the NSF-funded AstroCom program as well as the newly launched master's program in Astrophysics at the CUNY GC. Two new courses have been specifically designed to support the Astrophysics Specialization.
3. Changes to the ACP general introductory requirements. These changes are designed to improve the experience of all students throughout the early stages of their preparation and are built on the feedback that we have collected from students and faculty on the current curriculum.

The main advantage with the introduction of Specializations is to empower students with the flexibility to adapt the degree to their current academic needs and future employment plans. We will also continue to offer the traditional Computational Physics Specialization, which provides additional versatility and a lower degree of commitment to a specific theme.

All these programs will be unique in the CUNY system, giving new opportunities to students, helping to boost the enrollment in the ACP program, and overall providing a new opportunity for synergies between City Tech faculty and other academic institutions and companies in the NYC area.

### **Rationale for the new Quantum Specialization Rationale in ACP**

It is a universally acknowledged fact in the semiconductor and advanced manufacturing industries that the planned expansion of US-based semiconductor manufacturing and rapid emergence of quantum technologies are going to exacerbate the existing workforce shortage in those industries. One way to understand the magnitude of the impending shortage is to consider the state of NY based companies. For example, GlobalFoundries, a semiconductor chip manufacturer with a significant presence in upstate New York is currently building a fabrication facility in Malta, New York. Global Foundries estimates that once the new facility is completed, they will need approximately 5,000 additional staff to operate the new facility and are currently in discussions with all regional universities (including CUNY) to create a strategy for educating and recruiting this much needed workforce.

A recent study conducted by the SEMI Foundation, a strategic initiative aimed at mitigating the workforce shortage in the semiconductor industry, estimates that by the end of this decade 40,000 - 70,000 jobs in advanced semiconductor manufacturing will be created. Due to this demand, the recently signed CHIPS Act allocates \$11 Billion in funding for universities and educational institutions to create programs and educational opportunities that will address the semiconductor workforce shortage.

The proposed Quantum Technology Specialization will leverage the partnerships between the Physics and Chemistry Departments at City Tech and the Nanoscience Initiative of the ASRC and its Nanofabrication Facility, to create a cohort of students that will be trained to become part of the workforce that the new technology will require. The Nanoscience Initiative will work closely with our faculty to mentor the students.

Upon graduation, the students will hone numerous foundational skills and gain industry relevant knowledge, which are essential for and directly transferrable to all STEM related careers. These include experimental design; methods for data analysis, acquisition, and validation; the ability to effectively troubleshoot complex instrumentation; hardware-level programming. First-hand experience working with these technologies will significantly enhance the students' ability to easily enter, successfully compete in, and advance in the current STEM workforce.

### **Rationale for the new Astrophysics Specialization in ACP**

The creation of an Astrophysics Specialization within the Physics major will carry several benefits for our students and for the college and will significantly increase the enrollment in the Physics major.

We have witnessed in recent years a growing interest for more advanced Astrophysics classes from students. The Astrophysics Specialization will be unique in the CUNY system and attract students from other CUNY colleges (in particular, from the community colleges where we have several articulation agreements already in place), as well as other students from the NYC area.

The new Astrophysics Specialization will build on existing synergies, such as the one with the NSF-funded AstroCom program. This project, now in its tenth year of existence, involves CUNY undergraduates in academic research in Astrophysics, with the goal of boosting the percentage of

minority students pursuing graduate degrees in the physical sciences. Having the chance to take more advanced Astrophysics classes will be very helpful for students to be more successful in research, as well as to strengthen their graduate school applications.

The program will act as a natural steppingstone for the newly launched master's program in Astrophysics at the CUNY GC. This program provides tuition coverage and research funding for ten students every year and is designed as "a pathway for success for students of all backgrounds". CUNY graduates are ideally positioned to apply for this program, and a stronger curriculum in Astrophysics will bolster their chances of admission. Within the CUNY system, City Tech is uniquely placed to develop such as offer as it synergizes well with the heavily computational orientation of the BS degree, a core skillset for modern research in Astrophysics. It is also synergetic with the AstroCom NYC program which provides CUNY wide hands-on research opportunities in Astrophysics to our undergraduate students has enrolled several City Tech students in the past two years.

In addition to a robust preparation to graduate school for interested students, a concentration in Astrophysics provides an ideal transversal setting for the joint, hands-on exploration of advanced topics in physics, data science and supercomputing which are at the core of Modern Astrophysics. Therefore, this constitutes an excellent, naturally interdisciplinary preparation for students seeking a career in data science, machine learning or advanced computing (hydrodynamic simulations, AI, etc.). It is in fact extremely common for Astronomy graduates to secure industry positions in these fields where their versatile, yet rigorous skillset is appreciated. Hiring firms can range from IT companies to medical analytics or science communication among many others.

### **Rationale for the traditional Computational Physics Specialization**

In addition to the new Specializations, we will also continue to offer the traditional Computational Physics Specialization, which provides additional versatility and a lower degree of commitment to a specific theme.

The Computational Physics Specialization will offer a good background preparation for students that would like to pursue graduate school or looking for employments after graduation. All classes developed for the new Specializations will be available to students in the Computational Physics Specialization as electives, as well as computationally oriented classes offered by other Departments at City Tech within their degree programs.

### **Rationale for Changes in Introductory courses in ACP**

As the results of numerous conversations with students, as well as the outcome of a variety of program assessment activities, we have identified several areas in which our ACP curriculum can be further improved.

While the Specializations will take care of restructuring the advanced courses, we have also identified a series of important changes in the introductory courses, that will better prepare the students to face the challenges of the more advanced topic in Computational Physics.

**PHYS 2601 Introduction to Research.** We propose to introduce PHYS 2601 as a program requirement for all students in the ACP program. This class provides an interdisciplinary overview of all the important element of scientific inquiry, the mathematics related with analyzing sets of experimental data, and the computational skills that are needed to automate such calculations. The class will make extensive use of python as the computational language of choice. This will also prepare students to the more advanced applications in PHYS 3600, PHYS 4100 and PHYS 4150. To make room for this course, which is already on the catalog, we remove "CST 1204 Database Systems Fundamentals" from the degree requirement. While interesting, this class is too narrow in purpose, and will be suggested as an elective for students that have a specific interest in Database building.

**MAT 1630 Introduction to Computational Science.** This class offers a project-based introduction to computational thinking and problem solving, which align very well with the learning outcomes of the ACP program, in all the Specializations. We often suggested students to take this class as an elective, and their feedback was consistently positive. For these reasons, we would like to incorporate MAT 1630 as a program requirement, in alternative to “CST 1201 Programming Fundamentals”.

We have also decided to remove **PHYS 3300 Computational Fluid Dynamics** from list of program requirements. The course will still be available as an elective. Students in the Applied Computational Physics Specialization will be directed to take PHYS 2609 Intro to Quantum Computing.

### ACP Program Requirements

Here is a summary of the program requirements, after all the changes have been incorporated.

#### Computer Science and Mathematics Requirements: 21 cr (All Specializations)

CST 1101 Problem Solving with Computer Programming -- 3 cr  
 CST 1201 Programming Fundamentals -- 3 cr or MAT 1630 Introduction to Computational Science -- 3 cr  
 MAT 1475 Calculus I -- 4 cr  
 MAT 1575 Calculus II -- 4 cr  
 MAT 2675 Calculus III -- 4 cr  
 MAT 2580 Linear Algebra -- 3 cr

#### Applied Computational Physics (ACP) Core-Requirements: 39 cr (All Specializations)

PHYS 1441 General Physics I: Calculus based – 5 cr  
 PHYS 1442 General Physics II: Calculus based – 5 cr  
 PHYS 2443 Modern Physics -- 4 cr  
 PHYS 2601 Introduction to Research – 4 cr  
 PHYS 2607 Introduction to Quantum Mechanics -- 3 cr  
 PHYS 3100 Classical Mechanics -- 4 cr  
 PHYS 3200 Electricity and Magnetism -- 4 cr  
 PHYS 4100 Computational Methods -- 4 cr  
 PHYS 4150 Computational Methods Laboratory -- 2 cr  
 PHYS 4200 Internship/Real Research Experience – 4 cr

#### Astrophysics Specialization Additional Requirements: 14-15 cr

PHYS 2700 Introduction to Astrophysics – 4 cr  
 PHYS 3600 Machine Learning for Physics and Astronomy – 3 cr  
 PHYS 3700 Cosmology – 4 cr  
 One Additional PHYS Elective Course\* – 3 or 4 cr  
 (\*Non-PHYS elective allowed as well with permission from Program Coordinator)

#### Computational Physics Specialization Additional Requirements: 13-15 cr

PHYS 2609 Introduction to Quantum Computing 4 cr  
 PHYS 3600 Machine Learning for Physics and Astronomy 3 cr  
 Two Additional Physics Elective Courses\* – 3 or 4 cr each  
 (\*Non-PHYS electives allowed as well with permission from Program Coordinator)

#### Quantum Technology Specialization Additional Requirements: 17 cr

PHYS 1050 The Semiconductor World: From Coulomb to Compiler – 1 cr  
 PHYS 2501 Principles of Experimental Design I – 2 cr  
 PHYS 2502 Principles of Experimental Design II – 2 cr  
 PHYS 4500 Semiconductor Physics and Devices – 4 cr  
 CHEM 1110 General Chemistry I – 4 cr  
 CHEM 1210 General Chemistry II – 4 cr

**Free Elective classes (up to 120 credits).** While we don't impose any restrictions on the choice of elective classes, we strongly advise all students to discuss their plans with a Program Coordinator before signing up for classes. Program Coordinators will provide a list of suggested electives among the courses offered by the various Departments and Programs at City Tech, which will be updated every year.

### **New Proposed Courses for the Quantum Technology Specialization**

In this Section, we provide a short course description for each one of the New Courses that we plan to offer within the Quantum Technology and the Astrophysics Specializations of ACP. A full description, including syllabi, learning outcomes, and more specific details about the organization of each new course is provided in the "New Course Proposal Forms" collected in the Appendix of the Proposal.

#### **PHYS 1050 The Semiconductor World: From Coulomb to Compiler (1 Credit)**

This seminar course provides a broad conceptual overview of the major technologies which are enabled by semiconductor devices. The course begins with a brief overview of electronics and semiconductor physics with an emphasis on device design. Subsequent topics include the design and operation of logic gates, digital adders, microcontrollers, compilers, operating systems, computing algorithms, and quantum devices, and quantum computers. The topics for this course are selected from the disciplines of semiconductor physics, electrical engineering, and computer science. The course concludes with an overview of the micro and nanofabrication techniques which are used to make the devices discussed during the semester.

PREREQUISITES: None

#### **PHYS 2501 Principles of Experimental Design 1 (2 Credits)**

This is the first part of a two-semester sequence in experimental design. The goal of this sequence is to prepare students to work in academic and / or industrial Research and Development environments. After successfully completing the sequence, students will be able to design, build, and troubleshoot experiments, use automated computer-based techniques to collect, analyze and present the results of these experiments, discuss sources of error in the data they collected, and draw scientific conclusions from the data. The experiments which students will carry out in this course were chosen to impart skills and knowledge relevant to the field of semiconductor devices and engineering. Typical experiments, and the skills learned, during the first semester of the course include: Lab safety, Synthesis, Characterization, and Application of Quantum Dots as Sensitizers in Solar Cells, Open Cavity Helium-Neon Laser, Optical fibers for communication.

PRE/CO-REQUISITE: PHYS 1442

#### **PHYS 2502 Principles of Experimental Design 2 (2 Credits)**

This is the second part of a two-semester sequence in experimental design. The goal of this sequence is to prepare students to work in academic and / or industrial Research and Development environments. After successfully completing the sequence, students will be able to design, build, and troubleshoot experiments, use automated computer-based techniques to collect, analyze and present the results of these experiments, discuss sources of error in the data they collected, and draw scientific conclusions from the data. The experiments which students will carry out in this course were chosen to impart skills and knowledge relevant to the field of semiconductor devices and engineering. Typical experiments, and the skills learned, during the second semester of the course include: Microcontrollers and Automation, Transistor Operation, Introduction to the Cleanroom and Safety, Microchip contacts design, Electron Beam Lithography.

PREREQUISITES: PHYS 2501

**PHYS 4500 Semiconductor Physics (4 Credits)**

This course is an introduction to semiconductor science. Equal emphasis is placed on understanding the theoretical aspects of solid-state physics and the principles of design and operation of semiconductor devices, such as microelectronic and high frequency devices. Topics which will be discussed in the course include, a review of quantum physics, the basics of crystal structures and energy bands, carrier transport in solids, phonons, basic semiconductor measurements, *p-n* junctions, diodes and transistors, microwave devices, LEDs, LASERs, photodetectors, solar cells, and integrated devices. At the conclusion of the course students will also learn about the techniques used to fabricate semiconductor devices. Topics which will be discussed at the conclusion of the course include vacuum systems, plasma systems, optical lithography, electron beam lithography, physical vapor deposition techniques, chemical vapor deposition techniques, plasma etching, and device and wafer characterization methods.

PREREQUISITES: PHYS 1442

**PHYS 2700 Introduction to Astrophysics (4 Credits)**

This course offers an introduction to modern astrophysics covering such topics as observational techniques, stars, stellar physics, stellar evolution, star formation, extra-solar planets, the Milky Way and galaxies.

PRE/CO-REQUISITES: PHYS 1442

**PHYS 3700 Cosmology (4 Credits)**

An introduction to cosmology with applications to physical problems. Topics include fundamental observations, concepts of general relativity, evolution of the universe under different conditions, dark matter, cosmic gas and hydrodynamics, the cosmic microwave background, nucleosynthesis, inflation and the formation of structure in the universe.

PREREQUISITES: PHYS 1442

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## **Evidence of consultation with affected departments**

### **Letter from Prof. Jovanovic (Chair Chemistry Department)**

“The presented Quantum Technology Track proposal will benefit chemistry students in both programs- AS in Chemical Technology and BS in Applied Chemistry. Chemistry graduates will be trained to join the workforce to meet the emerging demand for the semiconductor industry and other emerging technologies. For example, undergraduate students can take some or all of the above proposed courses as electives (PHYS 1050, PHYS 2501, PHYS 2502, PHYS 4500) to specialize for potential jobs in relevant industry or further graduate studies in these fields. As mentioned previously, the Quantum Technology Track will synergize with the ASRC Nanoscience and Nanofabrication Facility and significantly strengthen chemistry curriculum, providing students with a broad set of laboratory skills in both physics and chemistry. In addition, students in BS program can also benefit if they declare an academic minor in Physics with the completed electives.”

### **Letter from Prof. Natov (Chair Mathematics Department)**

“Thank you for this proposal. I enthusiastically support these new proposed tracks in Astrophysics and Quantum Technology to the Applied Computational Physics degree. These will offer additional opportunities for Applied Computational Physics majors as well as City Tech students with the pre-requisites. Wishing you success.”

### **Letter from Prof. Satyanarayana (Chair Computer System Tech Department)**

“I want to express our wholehearted support for the expansion of your successful Applied Computational Physics program to include two exciting new tracks. The addition of the Quantum Technology Track and the Astrophysics Track will provide invaluable opportunities for our students as they pursue further education at the graduate level. Moreover, it will offer a well-rounded skillset in areas such as computing, machine learning, and physical modeling, making our graduates exceptionally well-prepared for diverse career paths in the industry.

We believe that these new tracks will not only enhance the educational experience of our students but also equip them with the knowledge and skills needed to thrive in their future endeavors. Your dedication to pushing the boundaries of our program and offering innovative opportunities for our students is commendable.

We look forward to supporting your efforts to implement these new tracks and eagerly anticipate the positive impact they will have on our students' academic and professional journeys.”

**Letter from Prof. Zameer (Chair Biology Department)**

“Thank you for sharing with me the proposal for the Quantum Technology and Astro tracks of the Applied Computational Physics bachelor’s degree at the Physics Department. I am convinced that opening these tracks is beneficial for City Tech students.

Specifically, these tracks will broaden the students’ employment opportunities and will help attract talented students to City Tech. I strongly support this proposal”.

## Minutes of Departmental Approval.

**NYC College of Technology  
School of Arts and Sciences  
Physics Department**

**Minutes of September 7, 2023, Department Meeting, 1:00PM, Room N-820 and via Zoom**

Presented F/T faculty: G. Kolmakov, V. Dorogan, G. Ossola, B. Gelman, D. Krym, L. Leng (remote), R. Kezerashvili, O. Berman (remote), A. Ferroglia

Absent F/T: S. Welker (traveling abroad), V. Aquaviva, A. Maller

### 1. Chair's announcements

Congratulations to Vladimir Kezerashvili with promotion to the rank of Adjunct Associate Professor!

The Chair reviewed the semester calendar of the remaining meeting dates for Department meetings, and Faculty Town Halls:

Department Meetings

- September 7, 1 pm
- October 5, 1 pm
- November 2, 1 pm
- December 7, 1 pm

A&S Faculty Town Hall

- Tue Oct 10 at 1PM

The Chair reviewed the academic calendar:

- Students can drop classes without grade penalty until December 11.
- We still can add students, please email the Chair if you have students to add.
- VOE roster
  - **Due on 9/14** for lecture classes on CUNYFirst
  - If 3 weeks of class meetings have not taken place by then, mark students as *Attending* and then submit WN later on if needed.

### 2. Quantum Tech & Astrophysics tracks proposals

Prof. Ossola presented two new tracks, Quantum Track and Astrophysics Track for the Applied Computational Physics major.

#### **Voting - F/T faculty:**

The department has voted for: "Proceed with the development and approval of the Quantum Technology and Astro tracks of the ACP major".

#### **The voting results:**

- Yes: 9
- No: 0
- Abstain: 0

### 3. Goods and welfare

Professor Kezerashvili announced his two papers published with students in peer-reviewed journals.

The meeting was adjourned at 1:47pm

Submitted by German Kolmakov

## APPENDIX – New Course Proposals ASTRO SPECIALIZATION

### PHYS 2700 Introduction to Astrophysics

New York City College of Technology, CUNY

#### NEW COURSE PROPOSAL FORM

This form is used for all new course proposals. Attach this to the [Curriculum Modification Proposal Form](#) and submit as one package as per instructions. Use one New Course Proposal Form for each new course.

<b>Course Title</b>	Introduction to Astrophysics
<b>Proposal Date</b>	09/10/23
<b>Proposer's Name</b>	C. Welker
<b>Course Number</b>	PHYS 2700
<b>Course Credits, Hours</b>	4 class hours, 4 credits
<b>Course Pre / Co-Requisites</b>	PHYS 1442
<b>Catalog Course Description</b>	This course offers an introduction to modern astrophysics covering such topics as; observational techniques, stars, stellar physics, stellar evolution, star formation, extra-solar planets, the Milky Way and galaxies.
<b>Brief Rationale</b> Provide a concise summary of why this course is important to the department, school or college.	This course is devoted to the application of physics to astrophysical phenomena.
<b>Intent to Submit as Common Core</b> If this course is intended to fulfill one of the requirements in the common core, then indicate which area.	This course will not be submitted to fulfill a common course requirement.
<b>Intent to Submit as An Interdisciplinary Course</b>	This course will not be submitted as an interdisciplinary course.
<b>Intent to Submit as a Writing Intensive Course</b>	This course will not be submitted as a writing intensive course.

#### Learning Outcomes and Assessments

##### *Discipline specific*

<b>Learning outcome</b>	<b>Assessment</b>
Students will learn to categorize stars by mass and temperature and understand how fusion powers stars.	homework, exams
Understand the possible end states of stars; white dwarfs, neutron stars and black holes.	homework, exams
Be able to describe the interstellar medium, its nebula and dust properties. Understand the relationship between the interstellar medium and star formation.	homework, exams
Learn about the detection of extra-solar planets and current understandings of planet formation.	homework, exams
Understand the basics of scattering theory	homework, exams

Learn the different types of galaxies and active galaxies, understand the physics of their formation and evolution.	homework, exams
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### *General Education*

<b>Learning outcomes</b>	<b>Assessment</b>
Upon completion of the course students should be able to apply the advanced mathematical techniques learned in the Calculus courses to real-life physical applications.	Class participation, homework assignments, final exam.
Explain phenomena observed in everyday life by applying the conceptual understanding of classical mechanics.	Class participation, homework assignments.
Apply scientific investigation and inquiry to understand real-world events.	Class participation, homework assignments.

Homework assignments and the final exam are based on problems similar to those at the end of the chapter in either textbook. Problems assigned will vary year to year as “Sample Problems” in the Example Weekly Course Outline. In order to pass the final exam a student should demonstrate the ability of solving at least 70% of the problems assigned in the test.

### **Example Weekly Course Outline:**

Week	Topic	Chapters Maoz	Chapters Carroll
1	Introduction and Overview	1	3
2	Stars: Observations	2	7,8
3	Stellar Physics	3	9,10
4	Stellar Evolution	4.1	13,15
5	Stellar Remnants	4.2 - 4.6	16
6	Star Formation	5.1-5.2	12.2-12.3
7	The Interstellar Medium	5.3-5.4	12.1
8	Extra - Solar Planets	6.1-6.2	23.1
9	Planet Formation Theory	6.3-6.4	23.2
10	The Milky Way	7.1	24
11	Galaxies: Observations	7.2	25
12	Active Galaxies	7.3	28
13	Galaxy Formation Theory	7.4	26
14	First Stars and Galaxies	-	-
15	Review and final exam	-	-

### **Grading Policy and Procedure**

*Scope of assignments and other course requirements:* Students will prepare homework assignments regularly. There will be one midterm exam and a final exam.

*Method of grading:* Students will be evaluated through homework and exams. The final grade will be based on a weighted average of the grades from the homework and exams as follows: One Midterm Exams 25%, Final Exam 35%, Homework 40%

## **Required and Recommended Instructional Materials**

### *Recommended textbooks:*

Astrophysics in a Nutshell: Second Edition, Dan Maoz, Princeton University Press (2016). ISBN-13: 978-0691164793

An Introduction to Modern Astrophysics, Bradley W. Carroll and Dale A. Ostlie, Cambridge University Press (2017). ISBN-13: 978-1108422161

## **College academic integrity policy**

Students and all others who work with information, ideas, texts, images, music, inventions, and other intellectual property owe their audience and sources accuracy and honesty in using, crediting, and citing sources. As a community of intellectual and professional workers, the College recognizes its responsibility for providing instruction in information literacy and academic integrity, offering models of good practice, and responding vigilantly and appropriately to infractions of academic integrity. Accordingly, academic dishonesty is prohibited in The City University of New York and at New York City College of Technology and is punishable by penalties, including failing grades, suspension, and expulsion.

## **College Policy on Absence/Lateness**

A student may be absent without penalty for 10% of the number of scheduled class meetings during the semester as follows:

<i>Class Meets</i>	<i>Allowable Absences</i>
1 time/week	2 classes
2 times/week	3 classes
3 times/week	4 classes

**Technology statement:** Before entering the course, students should be familiar with the use of a scientific calculator. During the course, students will develop some understanding of scientific computing.

## **Course Need Assessment**

**Target Students and Projected Head Counts:** This course will be a required upper level science course for the astro-track of the BS in Applied Computational Physics students. We will offer the course once per year, ideally in the Fall Semester, and anticipate that each year, all students in year 3 of their bachelor's degree studies will take the course. Thus, starting in the third year of the BS in Applied Computational Physics

program, we anticipate that there will be approximately 10 students taking the course. As the program grows, also the class enrollment will grow.

**Physical Resources:** No additional physical resources are necessary.

**Overlap with Other Courses:** This course covers topics that are also covered in PHYS1700. However, in this course the physics behind those phenomena are explored which is why PHYS 1441 and PHYS 1442 are required.

**Full Time Faculty:** The department does currently have full-time faculty capable of teaching this course.

### **Course Design**

PHYS 2700, Astrophysics, is a common course in bachelor programs in Physics and a required course for the astro-track of the ACP major. It will consist of 2 hour of lecture classes, twice per week, where the topics are introduced and applications illustrated. Homework will be assigned on a regular basis, which will prepare the students for their midterm and final tests.

### **Relationship to Programmatic Learning Outcomes**

This course will help students reach several programmatic learning outcomes of the Applied Computational Physics major. In particular, through this course students will:

- An appreciation of how the scientific method is built upon testable hypotheses and experimental evidence.
- A concrete foundation in basic physics, including mechanics, electromagnetism, quantum mechanics and thermodynamics.

**Chancellor's Report Form****Section AIV: New Courses****New courses to be offered in the Physics department**

<b>Department(s)</b>	Physics
<b>Academic Level</b>	<input checked="" type="checkbox"/> Regular <input type="checkbox"/> Compensatory <input type="checkbox"/> Developmental <input type="checkbox"/> Remedial
<b>Subject Area</b>	Physics
<b>Course Prefix</b>	PHYS
<b>Course Number</b>	2700
<b>Course Title</b>	<b>Astrophysics</b>
<b>Catalog Description</b>	This course offers an introduction to modern astrophysics covering such topics as; observational techniques, stars, stellar physics, stellar evolution, star formation, extra-solar planets, the Milky Way and galaxies.
<b>Prerequisite</b>	<b>PHYS 1442</b>
<b>Corequisite</b>	
<b>Pre-corequisite or</b>	
<b>Credits</b>	4
<b>Contact Hours</b>	4
<b>Liberal Arts</b>	<input checked="" type="checkbox"/> Yes <input type="checkbox"/> No
<b>Course Attribute (e.g. Writing Intensive, etc)</b>	
<b>Course Applicability</b>	<input checked="" type="checkbox"/> Major <input type="checkbox"/> Gen Ed Required <input type="checkbox"/> Gen Ed - Flexible <input type="checkbox"/> Gen Ed - College <input type="checkbox"/> English Composition <input type="checkbox"/> World Cultures <input type="checkbox"/> Speech <input type="checkbox"/> Mathematics <input type="checkbox"/> US Experience in its Diversity <input type="checkbox"/> Interdisciplinary <input type="checkbox"/> Science <input type="checkbox"/> Creative Expression <input checked="" type="checkbox"/> Advanced Liberal Arts <input type="checkbox"/> Individual and Society <input type="checkbox"/> Scientific World
<b>Effective Term</b>	

**Rationale** As one of the standard upper level physics courses required by any BS programs in Physics, this course is devoted to a detailed study of the laws of classical mechanics, by means of the appropriate mathematical tools acquired by the students in the Calculus sequence. Aside from providing students with the opportunity of applying and testing their mathematical and computational skills, this course provides a detailed description of the fundamental laws which are the basis of several technological applications.



## PHYS 3700 Cosmology

New York City College of Technology, CUNY  
NEW COURSE PROPOSAL FORM

This form is used for all new course proposals. Attach this to the [Curriculum Modification Proposal Form](#) and submit as one package as per instructions. Use one New Course Proposal Form for each new course.

<b>Course Title</b>	Cosmology
<b>Proposal Date</b>	09/10/23
<b>Proposer's Name</b>	Charlotte Welker
<b>Course Number</b>	PHYS 3700
<b>Course Credits, Hours</b>	4 class hours, 4 credits
<b>Course Pre / Co-Requisites</b>	PHYS 1442, MAT 1575
<b>Catalog Course Description</b>	
<b>Brief Rationale</b> Provide a concise summary of why this course is important to the department, school, or college.	A common upper-level physics course offered in BS programs in Physics, this course introduces the main ideas of cosmology by means of the appropriate mathematical tools acquired by the students in the Calculus sequence and not having had general relativity. Aside from providing students with the opportunity of applying and testing their mathematical and computational skills, this course provides a description of the Big Bang and the observations supporting it. Cosmology is the basis for understanding astrophysical phenomena all of which occur in the universe.
<b>Intent to Submit as Common Core</b> If this course is intended to fulfill one of the requirements in the common core, then indicate which area.	This course will not be submitted to fulfill a common course requirement.
<b>Intent to Submit as An Interdisciplinary Course</b>	This course will not be submitted as an interdisciplinary course.
<b>Intent to Submit as a Writing Intensive Course</b>	This course will not be submitted as a writing intensive course.

## Learning Outcomes and Assessments

*Discipline specific*

<b>Learning outcome</b>	<b>Assessment</b>
Learn basic ideas of General Relativity	homework, exams
Learn solutions to the evolution of the Universe based on its content	homework, exams
Learn the evidence for dark matter and possible candidates for it	homework, exams

Learn what causes the cosmic microwave background and what we can learn from observing it	homework, exams
Learn how Big Bang nucleosynthesis predicts the abundance of elements in the early universe	homework, exams
Learn the theory of inflation and what problems it attempts to solve	homework, exams

### *General Education*

<b>Learning outcomes</b>	<b>Assessment</b>
Upon completion of the course students should be able to apply the advanced mathematical techniques learned in the Calculus courses to real-life physical applications.	Class participation, homework assignments, final exam.
Explain phenomena observed in everyday life by applying the conceptual understanding electricity and magnetism.	Class participation, homework assignments.
Apply scientific investigation and inquiry to understand real-world events.	Class participation, homework assignments.

Homework assignments and the final exam are based on the solution of problems similar to those found at the end of each chapter in the course textbook. In order to pass the final exam a student should demonstrate the ability of solving at least 70% of the problems assigned in the test.

### **Required and Recommended Instructional Materials**

#### *Required text:*

- “Introduction to Cosmology”, 2nd Edition, B. **Ryden**, Cambridge University Press (2016). ISBN-13: 978 – 1107154834

#### *Additional Open-Source textbooks:*

- Introduction to Computational Astrophysical Hydrodynamics, M. **Zingale**, The Open Astrophysics Bookshelf.
- “ASTR 670 Hydrodynamics”, B. **Diemer**, U. of Maryland.

### **Grading Policy and Procedure**

*Scope of assignments and other course requirements:* Students will prepare homework assignments regularly. There will be a midterm exam and a final exam.

*Method of grading:* Students will be evaluated through homework and exams. The final grade will be based on a weighted average of the grades from the homework and exams as follows: Midterm exam 25%, Final Exam 35%, Homework 40%

### **Example Weekly Course Outline:**

Week	Topics	Chapter
1	Fundamental Observations	2 (Ryden)
2	Ideas of General Relativity	3-4 (Ryden)
3	Cosmic Dynamics and single-component Universes	4-5 (Ryden)
4	Multi-Component Universes and Cosmological Parameters	6-7 (Ryden)
5	Dark Matter	8 (Ryden)
6	Cosmic Gas: the hydrodynamics of the Universe	1-3 (Diemer)
7	Review and Midterm	-
8	Cosmic Microwave Background	9 (Ryden)
9	Simulations of the Universe	1-3 (Zingale)
10	Big Bang Nucleosynthesis	10.1 - 10.3 (Ryden)
11	Early Universe	10.4 - 10.5 (Ryden)
12	Inflation	11.1 - 11.4 (Ryden)
13	The Very Early Universe	11.5 (Ryden)
14	Formation of Structure	12 (Ryden)
15	Review and Final Exam	-

### College academic integrity policy

Students and all others who work with information, ideas, texts, images, music, inventions, and other intellectual property owe their audience and sources accuracy and honesty in using, crediting, and citing sources. As a community of intellectual and professional workers, the College recognizes its responsibility for providing instruction in information literacy and academic integrity, offering models of good practice, and responding vigilantly and appropriately to infractions of academic integrity. Accordingly, academic dishonesty is prohibited in The City University of New York and at New York City College of Technology and is punishable by penalties, including failing grades, suspension, and expulsion.

### College Policy on Absence/Lateness

A student may be absent without penalty for 10% of the number of scheduled class meetings during the semester as follows:

<i>Class Meets</i>	<i>Allowable Absences</i>
1 time/week	2 classes
2 times/week	3 classes
3 times/week	4 classes

**Technology statement:** Before entering the course, students should be familiar with the use of a scientific calculator. During the course, students will develop some understanding of scientific computing.

### Course Need Assessment

**Target Students and Projected Head Counts:** This course will be a required upper level science course for the astro-track of the BS in Applied Computational Physics. We will offer the course once per year, ideally in the Spring Semester. We anticipate that each year, all students in year 4 of their bachelor's degree studies will take the course. Thus, starting in the third year of the BS in Applied Computational Physics program, we anticipate that there will be approximately 10 students taking the course. As the program grows, also the class enrollment will grow.

**Physical Resources:** No additional physical resources are necessary.

**Overlap with Other Courses:** This course does not overlap with any other course offered at City Tech. Knowledge of the basic concepts of gravity, electricity, and magnetism (covered in PHYS 1441/1442 are important prerequisites for the more advanced course PHYS 3700. In a similar manner, it is important for students to review what they learned in the Calculus sequence, prior to taking PHYS 3700.

**Full Time Faculty:** The department does currently have full-time faculty capable of teaching this course.

### **Course Design**

PHYS 3700, Cosmology, is a common course in bachelor programs in Physics and a required course for the Astro track of the ACP major. Cosmology is often taught at the graduate level and is based on an understanding of general relativity. In this undergraduate version, principles of general relativity are explained, but students will not use the corresponding mathematics. Instead, arguments based on Newtonian gravity are used to motivate the results. PHYS 3700 will consist of two-hour lecture classes, twice per week, where the topics are introduced, and applications illustrated. Homework will be assigned on a regular basis, which will prepare the students for their midterm and final test.

### **Relationship to Programmatic Learning Outcomes**

This course will help students reach several programmatic learning outcomes of the Applied Computational Physics major. In particular, through this course students will:

- An appreciation of how the scientific method is built upon testable hypotheses and experimental evidence.
- A concrete foundation in basic physics, including mechanics, electromagnetism, quantum mechanics and thermodynamics.
- An awareness of the underlying assumptions and limitations of various approximation schemes and certain computational algorithms.

### **Chancellor's Report Form**

**Section AIV: New Courses****New courses to be offered in the Physics department**

<b>Department(s)</b>	Physics
<b>Academic Level</b>	<input checked="" type="checkbox"/> Regular <input type="checkbox"/> Compensatory <input type="checkbox"/> Developmental <input type="checkbox"/> Remedial
<b>Subject Area</b>	Physics
<b>Course Prefix</b>	PHYS
<b>Course Number</b>	3700
<b>Course Title</b>	<b>Cosmology</b>
<b>Catalog Description</b>	This course provides an introduction to cosmology for undergraduate students. Topics include concepts of general relativity, single component universes, multi-component universes, dark matter, the cosmic microwave background, big bang nucleosynthesis, and structure formation.
<b>Prerequisite</b>	<b>PHYS 1442, MAT 1575</b>
<b>Corequisite</b>	
<b>Pre- or corequisite</b>	
<b>Credits</b>	4
<b>Contact Hours</b>	4
<b>Liberal Arts</b>	<input checked="" type="checkbox"/> Yes <input type="checkbox"/> No
<b>Course Attribute (e.g. Writing Intensive, etc)</b>	
<b>Course Applicability</b>	<input checked="" type="checkbox"/> Major <input type="checkbox"/> Gen Ed Required <input type="checkbox"/> Gen Ed - Flexible <input type="checkbox"/> Gen Ed - College <input type="checkbox"/> English Composition <input type="checkbox"/> World Cultures <input type="checkbox"/> Speech <input type="checkbox"/> Mathematics <input type="checkbox"/> US Experience in its Diversity <input type="checkbox"/> Interdisciplinary <input type="checkbox"/> Science <input type="checkbox"/> Creative Expression <input checked="" type="checkbox"/> Advanced Liberal Arts <input type="checkbox"/> Individual and Society <input type="checkbox"/> Scientific World
<b>Effective Term</b>	

**Rationale:** As a common upper-level physics course offered in BS programs in Physics, this course introduces the main ideas of cosmology by means of the appropriate mathematical tools acquired by the students in the Calculus sequence and not having had general relativity. Aside from providing students with the opportunity of applying and testing their mathematical and computational skills, this course provides a description of the Big Bang and the observations supporting it. Cosmology is the basis for understanding astrophysical phenomena all of which occur in the universe.

## APPENDIX – New Course Proposals – QUANTUM SPECIALIZATION

### PHYS 1050 The Semiconductor World: From Coulomb to Compiler

New York City College of Technology, CUNY

#### NEW COURSE PROPOSAL FORM

This form is used for all new course proposals. Attach this to the [Curriculum Modification Proposal Form](#) and submit as one package as per instructions. Use one New Course Proposal Form for each new course.

<b>Course Title</b>	The Semiconductor World: From Coulomb to Compiler
<b>Proposal Date</b>	09/10/23
<b>Proposer's Name</b>	Vitaliy Dorogan
<b>Course Number</b>	PHYS 1050
<b>Course Credits, Hours</b>	1 credit, 1 seminar hour
<b>Course Pre / Co-Requisites</b>	None
<b>Catalog Course Description</b>	This seminar course provides a broad conceptual overview of the major technologies which are enabled by semiconductor devices. The course begins with a brief overview of electronics and semiconductor physics with an emphasis on device design. Subsequent topics include the design and operation of logic gates, digital adders, microcontrollers, compilers, operating systems, computing algorithms, and quantum devices, and quantum computers. The topics for this course are selected from the disciplines of semiconductor physics, electrical engineering, and computer science. The course concludes with an overview of the micro and nanofabrication techniques which are used to make the devices discussed during the semester.
<b>Brief Rationale</b> Provide a concise summary of why this course is important to the department, school or college.	This is a seminar type course that can be taken by any student with any background, no pre-requisite needed. It will serve as an interest seed for those who want to know more about the modern technologies and how they were made possible by semiconductors. The topics will be introduced through assigned readings (at home) and review lectures and discussions (in class). Some meetings will have invited speakers from other departments and industry. This course will be required for the Quantum Technology Track offered by the Physics Department. Also, this course can be designated as a free elective for Chemistry, Computer Science, and Engineering Programs.
<b>Intent to Submit as Common Core</b> If this course is intended to fulfill one of the requirements in the common core, then indicate which area.	This course will not be intended to fulfill a Common Core requirement.
<b>Intent to Submit as An Interdisciplinary Course</b>	This course will not be submitted as an Interdisciplinary course.

<b>Intent to Submit as a Writing Intensive Course</b>	This course will not be submitted as a writing intensive course.
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## Learning Outcomes and Assessments

### *Discipline specific*

<b>Learning outcome</b>	<b>Assessment</b>
Learn how mathematical calculations, algorithms, and semiconductor devices solve the needs of Information technology	Homework; in-class discussion
Learn a basic concept and understand the principle of operation of a diode	Homework; in-class discussion
Learn a basic concept and understand the principle of operation of a transistor	Homework; in-class discussion
Learn concepts of logical elements	Homework; in-class discussion
Learn basic ideas and concepts of quantum computing	Homework; in-class discussion
Learn basic ideas of micro- and nanofabrication	Homework; in-class discussion

### *General Education*

<b>Learning outcomes</b>	<b>Assessment</b>
Learn how to lead a discussion, how to brainstorm ideas, how to work in a team	In-class discussions and activities
Learn how to write a short analytical reflection on the chosen topic	Homework assignments
Develop elevator-pitch type presentation skills	One-slide presentations

### **Structure of the Seminar Course:**

Each class meeting will consist of a short review lecture, discussion, and class activities. Sometimes, external speakers from various fields will be invited to class. The students will be assigned a short, targeted reading that should be done before the discussion in class. The students will also write a one-paragraph reflection based on the assigned reading (pre-discussion). After the topic is discussed in class the students will add a post-discussion part (new thoughts and ideas) to their reflection and submit it to the instructor. For the Final Presentation, students will choose a topic and make a one-slide short presentation (5min = 3min presentation + 2min questions).

### **Example Weekly Course Outline:**

<b>Week</b>	<b>Topics</b>	<b>Assigned Reading</b>
1	Introduction: Course overview	TBD
2	Historical aspects of Information Technology	TBD
3	Semiconductors: Materials with tunable properties	TBD
4	Building blocks of electronics: Diodes and Transistors	TBD
5	***Discussion with invited speaker from Electrical Engineering	TBD

6	Logical gates, Digital adders	TBD
7	Microcontrollers, Compilers	TBD
8	Computing Algorithms and Operation Systems	TBD
9	***Discussion with invited speaker from Computer Science	TBD
10	Basics of Quantum Physics	TBD
11	Quantum Computers and their applications	TBD
12	***Discussion with invited speaker from Semiconductor industry	TBD
13	Microelectronics: Microfabrication techniques	TBD
14	Nanotechnology: Nanofabrication techniques	TBD
15	Final Presentations	

### Grading Policy and Procedure

- ◆ Class participation (attendance, activities, kahoot quizzes) = 20%
- ◆ 12 written one-page reflections (one dropped) = 60%
- ◆ Final Presentation = 20%

### Required and Recommended Instructional Materials

All materials will be provided either in the form of Power-Point presentations or as web-based resources such as articles, book chapters, YouTube videos, etc.



**Chancellor's Report Form****Section AIV: New Courses****New courses to be offered in the Physics department**

<b>Department(s)</b>	Physics
<b>Academic Level</b>	<input checked="" type="checkbox"/> Regular <input type="checkbox"/> Compensatory <input type="checkbox"/> Developmental <input type="checkbox"/> Remedial
<b>Subject Area</b>	Physics
<b>Course Prefix</b>	PHYS
<b>Course Number</b>	1050
<b>Course Title</b>	The Semiconductor World: From Coulomb to Compiler
<b>Catalog Description</b>	This seminar course provides a broad conceptual overview of the major technologies which are enabled by semiconductor devices. The course begins with a brief overview of electronics and semiconductor physics with an emphasis on device design. Subsequent topics include the design and operation of logic gates, digital adders, microcontrollers, compilers, operating systems, computing algorithms, and quantum devices, and quantum computers. The topics for this course are selected from the disciplines of semiconductor physics, electrical engineering, and computer science. The course concludes with an overview of the micro and nanofabrication techniques which are used to make the devices discussed during the semester.
<b>Prerequisite</b>	None
<b>Corequisite</b>	
<b>Pre-corequisite or</b>	
<b>Credits</b>	1
<b>Contact Hours</b>	1
<b>Liberal Arts</b>	<input checked="" type="checkbox"/> Yes <input type="checkbox"/> No
<b>Course Attribute (e.g. Writing Intensive, etc)</b>	
<b>Course Applicability</b>	<input checked="" type="checkbox"/> Major <input type="checkbox"/> Gen Ed Required <input type="checkbox"/> Gen Ed - Flexible <input type="checkbox"/> Gen Ed - College <input type="checkbox"/> English Composition <input type="checkbox"/> World Cultures <input type="checkbox"/> Speech <input type="checkbox"/> Mathematics <input type="checkbox"/> US Experience in its Diversity <input type="checkbox"/> Interdisciplinary <input type="checkbox"/> Science <input type="checkbox"/> Creative Expression <input type="checkbox"/> Advanced Liberal Arts <input type="checkbox"/> Individual and Society <input type="checkbox"/> Scientific World
<b>Effective Term</b>	

**Rationale** This is a seminar type course that can be taken by any student with any background, no pre-requisite needed. It will serve as an interest seed for those who want to know more about the modern technologies and how they were made possible by semiconductors. The topics will be introduced through assigned readings (at home) and review lectures and discussions (in class).

Some meetings will have invited speakers from other departments and industry. This course will be required for the Quantum Technology Track offered by the Physics Department. Also, this course can be designated as a free elective for Chemistry, Computer Science, and Engineering Programs.

**PHYS 2501 Principles of Experimental Design I**

New York City College of Technology, CUNY

## NEW COURSE PROPOSAL FORM

This form is used for all new course proposals. Attach this to the [Curriculum Modification Proposal Form](#) and submit as one package as per instructions. Use one New Course Proposal Form for each new course.

<b>Course Title</b>	PHYS 2501 Principles of Experimental Design I
<b>Proposal Date</b>	09/10/23
<b>Proposer's Name</b>	Vitaliy Dorogan, Todd Gelbord, Ivana Jovanovic, Lufeng Leng
<b>Course Number</b>	PHYS 2501
<b>Course Credits, Hours</b>	2 credit, 4 lab hours
<b>Course Pre / Co-Requisites</b>	PHYS 1442 (Pre), CHEM1100 (Pre/Co)
<b>Catalog Course Description</b>	This is a two-semester sequence in experimental design. The goal of this sequence is to prepare students for work in academic and / or industrial Research and Development environments by learning how to design, build, and troubleshoot experiments, use automated computer-based techniques to collect, analyze and present the results of these experiments, discuss sources of error in the data they collected, and draw scientific conclusions from the data. The experiments carried out in this course will impart skills and knowledge relevant to the fields of photonics, semiconductor devices and engineering.
<b>Brief Rationale</b> Provide a concise summary of why this course is important to the department, school or college.	Students need essential skills that are foundational to all STEM careers. These include experimental design; methods for data analysis, acquisition, and validation; the ability to effectively troubleshoot complex instrumentation; hardware-level programming; and many others. Students will also need to further develop their presentation skills by making figures and reports and presenting findings to their diverse research groups. Students will have the opportunity to receive and provide feedback on their presentations to further strengthen their knowledge. As a result of hands-on training the students will master many of the concepts and skills taught in CUNY STEM courses and receive hands-on experience in working with and designing advanced electronic and photonic circuits, vacuum systems, plasma systems, electron beam technology, and/or advanced metrology equipment. These technologies are ubiquitous across STEM industries.
<b>Intent to Submit as Common Core</b>	This course will not be intended to fulfill a Common

If this course is intended to fulfill one of the requirements in the common core, then indicate which area.	Core requirement.
<b>Intent to Submit as An Interdisciplinary Course</b>	This course will not be submitted as an Interdisciplinary course.
<b>Intent to Submit as a Writing Intensive Course</b>	This course will not be submitted as a writing intensive course.

## Learning Outcomes and Assessments

### *Discipline specific*

Learning outcome	Assessment
<p><b>Quantum Dot Physics and Chemistry:</b> Students will learn about semiconductor nanoparticles, and differences in their properties based on their size. They'll learn about the concepts of kinetic and thermodynamic stability. Students will learn how to prepare solutions, dilute solutions, measure absorption and emission spectra using a spectrophotometer. This lab will demonstrate applications of nanomaterials, as they build a photovoltaic device. Students will learn about the components of such a device, and how the light can be converted into electricity. Students will practice plotting graphs and analyze spectra obtained after the measurements.</p> <ul style="list-style-type: none"> <li>• <b>Lab 1:</b> Synthesis, Characterization, and Application of CdS Quantum Dots as Sensitizers in Solar Cells (<i>Sessions 1 - 5</i>)</li> </ul>	<ul style="list-style-type: none"> <li>• Lab report</li> <li>• Lab notebook</li> </ul>
<p><b>Laser and Optical Fiber Physics:</b> Students will gain hands-on experience by successfully constructing and operating an open cavity He-Ne laser. They will learn how to characterize a laser by measuring the output wavelength and power, and by identifying the various transverse modes in the far field. Students will also obtain hands-on experience in common practices in the optical fiber communication industry, including terminating and troubleshooting a fiber link.</p> <ul style="list-style-type: none"> <li>• <b>Lab 2:</b> Open Cavity Helium-Neon Laser (<i>Sessions 6 - 9</i>)</li> <li>• <b>Lab 3:</b> Optical fibers for communication (<i>Sessions 10 - 14</i>)</li> </ul>	<ul style="list-style-type: none"> <li>• Lab report</li> <li>• Lab notebook</li> </ul>

### *General Education*

Learning outcomes	Assessment

<p>Upon completion of the course, students should be able to acquire and practice advanced laboratory skills including gathering, analyzing and interpreting complex data.</p> <p>Upon completion of the course, students should be able to present laboratory findings in a clear, concise laboratory report at a near-professional level.</p> <p>Discuss the scope of physics and chemistry as natural sciences, and practical applications of fundamental research to real world problems.</p>	<ul style="list-style-type: none"> <li>• Lab report</li> <li>• Lab notebook</li> <li>• Class/experiment Participation</li> <li>• Final Presentation</li> </ul>
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### Example Weekly Course Outline:

Week	Topics
1 - 5	<p>Check-in.</p> <p>Introduction to the course.</p> <p>Lab safety.</p> <p>Synthesis, Characterization, and Application of CdS Quantum Dots as Sensitizers in Solar Cells</p>
6 - 9	Open Cavity Helium-Neon Laser
10 - 14	Optical fibers for communication
15	Final Presentation

### Grading Policy and Procedure

- **Semester 1:**
  - **Lab 1** - 28%
  - **Lab 2** - 28%
  - **Lab 3** - 28%
  - **Final Presentation** - 16%

### Lab Class Evaluation Methods and Criteria

## Written lab reports and lab notebook:

- Students will write one laboratory report for each of the laboratory exercises. Laboratory reports will follow the structure of scientific publications. The format includes the following sections: abstract, introduction, experimental procedures, results and discussion, conclusion, and references. Students will also be required to maintain a laboratory notebook that will be collected at the end of the semester.

## Laboratory participation:

- Students' participation in the lab is extremely important because laboratory techniques are learned by doing. Students must participate in a minimum of 13 of the 15 scheduled laboratory sessions in order to pass the course. Students will be evaluated on 1) readiness for the experiment, 2) active participation in the lab, 3) proper execution of laboratory techniques, and 4) compliance with safety procedures.

## Oral Presentation:

- Students will be assigned one of the experiments performed during the semester to present the results in a group oral presentation. The oral presentation will be evaluated according to its structure, scientific content, and clarity.

## Required and Recommended Instructional Materials

### Required Lab Gear and Equipment:

- Approved safety goggles
- Laboratory coat
- Laboratory notebook

### Required Texts

- For Lab 1 the manual will be provided by the department; adopted from Bauer et al, "An Integrated, Multipart Experiment- Synthesis, Characterization, and Application of CdS and CdSe Quantum Dots as Sensitizers in Solar Cells", J. Chem. Educ. 2018, 95, 1179–1186
- For Labs 2 & 3, the manual will be provided by the department.

### Recommended Texts

- R. S. Quimby, "Photonics and Lasers: An Introduction", 2006, Wiley-Interscience.

**Technology Statement:** Before entering the course, students must be familiar with MS Word, MS Excel (simple spreadsheet calculations and graphing), and PowerPoint. During this course, students will learn how to convert between different data file types and how to import text file data into graphing software.

**Accessibility Statement:** City Tech is committed to supporting the educational goals of enrolled students with disabilities in the areas of enrollment, academic advisement, tutoring, assistive technologies, and testing accommodations. If you have or think you may have a disability, you may be eligible for reasonable accommodations or academic adjustments as provided under applicable federal, state and city laws. You may also request services for temporary conditions or medical issues under certain circumstances. If you have questions about your eligibility or would like to seek accommodation services

or academic adjustments, please contact the Center for Student Accessibility at 300 Jay Street room L-237, 718 260 5143 or <http://www.citytech.cuny.edu/accessibility>.

**Academic Integrity Policy Statement:** Students and all others who work with information, ideas, texts, images, music, inventions, and other intellectual property owe their audience and sources accuracy and honesty in using, crediting, and citing sources. As a community of intellectual and professional workers, the College recognizes its responsibility for providing instruction in information literacy and academic integrity, offering models of good practice, and responding vigilantly and appropriately to infractions of academic integrity. Accordingly, academic dishonesty is prohibited in The City University of New York and at New York City College of Technology and is punishable by penalties, including failing grades, suspension, and expulsion. The complete text of the College policy on Academic Integrity may be found in the catalog.

### **Chancellor's Report Form**

#### **Section AIV: New Courses**

##### **AIV.1. Physics**

**Course Number:** PHYS 2501

**Title:** Principles of Experimental Design 1

**Hours:** 4 Lab Hours

**Credits:** 2

**Prerequisites:** PHYS 1442 (Pre), CHEM 1110 (Pre/Co) →?

**Course Description:** This is a two-semester sequence in experimental design. The goal of this sequence is to prepare students for work in academic and / or industrial Research and Development environments by learning how to design, build, and troubleshoot experiments, use automated computer-based techniques to collect, analyze and present the results of these experiments, discuss sources of error in the data they collected, and draw scientific conclusions from the data. The experiments carried out in this course will impart skills and knowledge relevant to the fields of photonics, semiconductor devices and engineering

**Rationale:** Students need essential skills that are foundational to all STEM careers. These include experimental design; methods for data analysis, acquisition, and validation; the ability to effectively troubleshoot complex instrumentation; hardware-level programming; and many others. Students will also need to further develop their presentation skills by making figures and reports and presenting findings to their diverse research groups. Students will have the opportunity to receive and provide feedback on their presentations to further strengthen their knowledge. As a result of hands-on training the students will master many of the concepts and skills taught in CUNY STEM courses and receive hands-on experience in working with and designing advanced electronic and photonic circuits, vacuum systems, plasma systems, electron beam technology, and/or advanced metrology equipment. These technologies are ubiquitous across STEM industries.

**PHYS 2502 Principles of Experimental Design II**

New York City College of Technology, CUNY

## NEW COURSE PROPOSAL FORM

This form is used for all new course proposals. Attach this to the [Curriculum Modification Proposal Form](#) and submit as one package as per instructions. Use one New Course Proposal Form for each new course.

<b>Course Title</b>	Principles of Experimental Design II
<b>Proposal Date</b>	09/10/23
<b>Proposer's Name</b>	Vitaliy Dorogan, Todd Gelbord, Ivana Jovanovic, Lufeng Leng
<b>Course Number</b>	PHYS 2502
<b>Course Credits, Hours</b>	2 credit, 4 lab hours
<b>Course Pre / Co-Requisites</b>	PHYS 1501 (Pre)
<b>Catalog Course Description</b>	This is a two-semester sequence in experimental design. The goal of this sequence is to prepare students for work in academic and / or industrial Research and Development environments by learning how to design, build, and troubleshoot experiments, use automated computer-based techniques to collect, analyze and present the results of these experiments, discuss sources of error in the data they collected, and draw scientific conclusions from the data. The experiments carried out in this course will impart skills and knowledge relevant to the fields of photonics, semiconductor devices and engineering.
<b>Brief Rationale</b> Provide a concise summary of why this course is important to the department, school or college.	Students need essential skills that are foundational to all STEM careers. These include experimental design; methods for data analysis, acquisition, and validation; the ability to effectively troubleshoot complex instrumentation; hardware-level programming; and many others. Students will also need to further develop their presentation skills by making figures and reports and presenting findings to their diverse research groups. Students will have the opportunity to receive and provide feedback on their presentations to further strengthen their knowledge. As a result of hands-on training the students will master many of the concepts and skills taught in CUNY STEM courses and receive hands-on experience in working with and designing advanced electronic and photonic circuits, vacuum systems, plasma systems, electron beam technology, and/or advanced metrology equipment. These technologies are ubiquitous across STEM industries.



<b>Intent to Submit as Common Core</b> If this course is intended to fulfill one of the requirements in the common core, then indicate which area.	This course will not be intended to fulfill a Common Core requirement.
<b>Intent to Submit as An Interdisciplinary Course</b>	This course will not be submitted as an Interdisciplinary course.
<b>Intent to Submit as a Writing Intensive Course</b>	This course will not be submitted as a writing intensive course.

## Learning Outcomes and Assessments

*Discipline specific*

Learning outcome	Assessment
<p><b>Microcontroller and Transistor Physics:</b> Students will learn the Arduino coding language, the fundamentals of microcontroller operation and programming, and the physical operation of automated microfabrication. Furthermore, they will learn the physical principles of how transistors work and what they do, as well as how different semiconductors can create different transistors by simulating their operation and composition via code. Students will also learn how transistors are used to produce logic gates and ultimately rudimentary computation.</p> <ul style="list-style-type: none"> <li>• <b>Lab 1:</b> Intro to Microcontrollers, Arduino, and the physics of automation (<i>Sessions 1 - 4</i>)</li> <li>• <b>Lab 2:</b> Introduction to Transistor Operation (<i>Sessions 5 - 6</i>)</li> </ul>	<ul style="list-style-type: none"> <li>• Lab report</li> <li>• Lab notebook</li> </ul>
<p><b>Electron Beam Physics and Chemistry:</b> The students will develop practical skills of using the AutoCAD and WECAS software. In addition, students will be introduced to the cleanroom environment. Students will also acquire hands-on skills on using the resist spinner, develop understanding of the thickness measurement, baking, and microscope use. Finally, students will acquire hands-on skills in using electron beam lithography equipment, chemical development of the structures, and computer-assisted microphotography in a cleanroom.</p>	<ul style="list-style-type: none"> <li>• Lab report</li> <li>• Lab notebook</li> </ul>

<ul style="list-style-type: none"> <li>• <b>Lab 3:</b> Microchip contacts design and file preparation for writing with electron-beam (<i>Sessions 7 - 9</i>)</li> <li>• <b>Lab 4:</b> Spinning electron beam resist (<i>Sessions 10 - 12</i>)</li> <li>• <b>Lab 5:</b> Electron Beam Lithography (<i>Sessions 13 - 14</i>)</li> </ul>	
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### General Education

Learning outcomes	Assessment
<p>Upon completion of the course, students should be able to acquire and practice advanced laboratory skills including gathering, analyzing and interpreting complex data.</p> <p>Upon completion of the course, students should be able to present laboratory findings in a clear, concise laboratory report at a near-professional level.</p> <p>Discuss the scope of physics and chemistry as natural sciences, and practical applications of fundamental research to real world problems.</p>	<ul style="list-style-type: none"> <li>• Lab report</li> <li>• Lab notebook</li> <li>• Class/experiment Participation</li> <li>• Final Presentation</li> </ul>

### Example Weekly Course Outline:

Week	Topics
1 - 4	Introduction to the course and intro to Microcontrollers, Arduino, and the physics of automation
5 - 6	Introduction to Transistor Operation

7 - 9	Introduction to the Cleanroom and Safety  Microchip contacts design and file preparation for writing with electron-beam
10 - 11	Spinning Electron Beam Resist
12 - 14	Electron Beam Lithography
15	Final Presentation

### Grading Policy and Procedure

- **Semester 2:**
  - **Lab 1** - 17%
  - **Lab 2** - 17%
  - **Lab 3** - 17%
  - **Lab 4** - 17%
  - **Lab 5** - 17%
  - **Final Presentation** - 15%

### Lab Class Evaluation Methods and Criteria

#### Written lab reports and lab notebook:

- Students will write one laboratory report for each of the laboratory exercises. Laboratory reports will follow the structure of scientific publications. The format includes the following sections: abstract, introduction, experimental procedures, results and discussion, conclusion, and references. Students will also be required to maintain a laboratory notebook that will be collected at the end of the semester.

#### Laboratory participation:

- Students' participation in the lab is extremely important because laboratory techniques are learned by doing. Students must participate in a minimum of 13 of the 15 scheduled laboratory sessions in order to pass the course. Students will be evaluated on 1) readiness for the experiment, 2) active participation in the lab, 3) proper execution of laboratory techniques, and 4) compliance with safety procedures.

## Oral Presentation:

- Students will be assigned one of the experiments performed during the semester to present the results in a group oral presentation. The oral presentation will be evaluated according to its structure, scientific content, and clarity.

## Required and Recommended Instructional Materials

### Required Lab Gear and Equipment:

- Approved safety goggles
- Laboratory coat
- Laboratory notebook

### Required Texts

- Provided by the department

### Recommended Texts

- Arduino's online documentation (free)
- *Programming Arduino: Getting Started with Sketches*, S. Monk
- *Programming Arduino Next Steps: Going Further with Sketches*, S. Monk
- *Arduino: A Technical Reference*, J. M. Hughes
- *Arduino Cookbook*, M. Margolis, B. Jepson, N. R. Weldin
- *The Art of Electronics* by Horowitz and Hill

**Technology Statement:** Before entering the course, students must be familiar with MS Word, MS Excel (simple spreadsheet calculations and graphing), and PowerPoint. During this course, students will learn how to convert between different data file types and how to import text file data into graphing software.

**Accessibility Statement:** City Tech is committed to supporting the educational goals of enrolled students with disabilities in the areas of enrollment, academic advisement, tutoring, assistive technologies, and testing accommodations. If you have or think you may have a disability, you may be eligible for reasonable accommodations or academic adjustments as provided under applicable federal, state and city laws. You may also request services for temporary conditions or medical issues under certain circumstances. If you have questions about your eligibility or would like to seek accommodation services or academic adjustments, please contact the Center for Student Accessibility at 300 Jay Street room L-237, 718 260 5143 or <http://www.citytech.cuny.edu/accessibility>.

**Academic Integrity Policy Statement:** Students and all others who work with information, ideas, texts, images, music, inventions, and other intellectual property owe their audience and sources accuracy and honesty in using, crediting, and citing sources. As a community of intellectual and professional workers, the College recognizes its

responsibility for providing instruction in information literacy and academic integrity, offering models of good practice, and responding vigilantly and appropriately to infractions of academic integrity. Accordingly, academic dishonesty is prohibited in The City University of New York and at New York City College of Technology and is punishable by penalties, including failing grades, suspension, and expulsion. The complete text of the College policy on Academic Integrity may be found in the catalog.

### **Chancellor's Report Form**

#### **Section AIV: New Courses**

##### **AIV.1. Physics**

**Course Number:** PHYS 2502

**Title:** Principles of Experimental Design 2

**Hours:** 4 Lab Hours

**Credits:** 2

**Prerequisites:** PHYS 2501 (Pre)

**Course Description:** This is a two-semester sequence in experimental design. The goal of this sequence is to prepare students for work in academic and / or industrial Research and Development environments by learning how to design, build, and troubleshoot experiments, use automated computer-based techniques to collect, analyze and present the results of these experiments, discuss sources of error in the data they collected, and draw scientific conclusions from the data. The experiments carried out in this course will impart skills and knowledge relevant to the fields of photonics, semiconductor devices and engineering.

**Rationale:** Students need essential skills that are foundational to all STEM careers. These include experimental design; methods for data analysis, acquisition, and validation; the ability to effectively troubleshoot complex instrumentation; hardware-level programming; and many others. Students will also need to further develop their presentation skills by making figures and reports and presenting findings to their diverse research groups. Students will have the opportunity to receive and provide feedback on their presentations to further strengthen their knowledge. As a result of hands-on training the students will master many of the concepts and skills taught in CUNY STEM courses and receive hands-on experience in working with and designing advanced electronic and photonic circuits, vacuum systems, plasma systems, electron beam technology, and/or advanced metrology equipment. These technologies are ubiquitous across STEM industries.

**PHYS 4500 Semiconductor Physics and Devices**

New York City College of Technology, CUNY

## NEW COURSE PROPOSAL FORM

This form is used for all new course proposals. Attach this to the [Curriculum Modification Proposal Form](#) and submit as one package as per instructions. Use one New Course Proposal Form for each new course.

<b>Course Title</b>	Semiconductor Physics and Devices
<b>Proposal Date</b>	10/5/23
<b>Proposer's Name</b>	German Kolmakov
<b>Course Number</b>	PHYS 4500
<b>Course Credits, Hours</b>	4 cr, 4 hrs/week (60 hrs/semester)
<b>Course Pre / Co-Requisites</b>	PHYS 2443 or PHYS 2607 or PHYS 2502
<b>Catalog Course Description</b>	This course is an introduction to semiconductor science. Equal emphasis is placed on understanding the theoretical aspects of solid-state physics and the principles of design and operation of semiconductor devices, such as microelectronic and high frequency devices. Topics which will be discussed in the course include, a review of quantum physics, the basics of crystal structures and energy bands, carrier transport in solids, phonons, basic semiconductor measurements, <i>p-n</i> junctions, diodes and transistors, microwave devices, LEDs, lasers, photodetectors, solar cells, and integrated devices. At the conclusion of the course students will also learn about the tools and techniques of modern micro and nanofabrication used to fabricate semiconductor devices. Topics which will be discussed at the conclusion of the course include: vacuum systems, plasma systems, optical lithography, electron beam lithography, physical vapor deposition techniques, chemical vapor deposition techniques, plasma etching, and device and wafer characterization methods.
<b>Brief Rationale</b> Provide a concise summary of why this course is important to the department, school or college.	This course provides important basics for understanding semiconductor physics for students. The course educates students about the relevant area of physics itself as well as applications in actual devices. This course will be required for the Quantum Technology Track offered by the Physics Department. Also, this course can be designated as a free elective for Chemistry, Computer Science, and Engineering Programs.
<b>Intent to Submit as Common Core</b> If this course is intended to fulfill one of the requirements in the common core, then indicate which area.	This course will not be intended to fulfill a Common Core requirement.
<b>Intent to Submit as An Interdisciplinary Course</b>	This course will not be submitted as an interdisciplinary course.
<b>Intent to Submit as a Writing Intensive Course</b>	This course will not be submitted as a writing intensive course.

## Learning Outcomes and Assessments

### *Discipline specific*

Learning outcome	Assessment
Understand the composition and basic energy structure of semiconductors	Homework; in-class discussion
Learn about the charge carrier statistics and dynamics in semiconductors	Homework; in-class discussion
Understand principles behind semiconducting devices including transistors, LEDs, lasers and solar cells.	Homework; in-class discussion
Theoretically learn the main techniques of fabrication of semiconducting devices.	Homework; in-class discussion

### *General Education*

Learning outcomes	Assessment
Learn how mathematical calculations, algorithms, and semiconductor devices solve the needs of Information technology	Homework; in-class discussion
Learn how to write a short analytical reflection on the chosen topic	Homework; in-class discussion
Develop elevator-pitch type presentation skills	Homework; in-class discussion

### Example Weekly Course Outline:

Week	Topics
1	Review of quantum theory of semiconductors
2	Carrier statistics
3	Electric currents in semiconductors
4	Carrier dynamics, effects of phonons
5	Optical properties of semiconductors. 1 <sup>st</sup> midterm exam
6	Excitonic states in semiconductors
7	Heterojunctions, Schottky barriers, Ohmic contacts
8	Field effect transistors
9	MOSFET, Work function difference
10	Bipolar junction transistors, terminal current, 2 <sup>nd</sup> midterm exam
11	Photonics, radiative transition, emission spectra, LED
12	Solar cell and photodetectors, conversion frequency, spectral response
13	Review of vacuum systems and vacuum pumps
14	Lithography, deposition technique, etching
15	Review and Final exam

### Grading Policy and Procedure

- Two midterm exams = 50% (that is, 25% each midterm exam)

- Final Exam = 25%
- Homework and in-call assignments = 25%

### **Required and Recommended Instructional Materials**

For this course, the required textbooks are:

- S. M. Sze, Y. Li, K. K. Ng, “Physics of Semiconductor Devices”, 4th ed, Wiley, (ISBN: 978-1-119-42911-1).
- Donald Neamen, "Semiconductor Physics and Devices", 4th Edition, ISBN10: 0073529583, (ISBN: 9780073529585).
- Hans H. Gatzert, Volker Saile, Jürg Leuthold, “Micro and Nano Fabrication: Tools and Processes,” ISBN-13: 978-3662443941



**Chancellor's Report Form****Section AIV: New Courses****New courses to be offered in the Physics department**

<b>Department(s)</b>	Physics
<b>Academic Level</b>	<input checked="" type="checkbox"/> Regular <input type="checkbox"/> Compensatory <input type="checkbox"/> Developmental <input type="checkbox"/> Remedial
<b>Subject Area</b>	Physics
<b>Course Prefix</b>	PHYS
<b>Course Number</b>	4500
<b>Course Title</b>	Semiconductor Physics and Devices
<b>Catalog Description</b>	This course is an introduction to semiconductor science. Equal emphasis is placed on understanding the theoretical aspects of solid-state physics and the principles of design and operation of semiconductor devices, such as microelectronic and high frequency devices. Topics which will be discussed in the course include, a review of quantum physics, the basics of crystal structures and energy bands, carrier transport in solids, phonons, basic semiconductor measurements, <i>p-n</i> junctions, diodes and transistors, microwave devices, LEDs, lasers, photodetectors, solar cells, and integrated devices. At the conclusion of the course students will also learn about the tools and techniques of modern micro and nanofabrication used to fabricate semiconductor devices. Topics which will be discussed at the conclusion of the course include: vacuum systems, plasma systems, optical lithography, electron beam lithography, physical vapor deposition techniques, chemical vapor deposition techniques, plasma etching, and device and wafer characterization methods.
<b>Prerequisite</b>	PHYS 2443 or PHYS 2607 or PHYS 2502
<b>Corequisite</b>	
<b>Pre-corequisite or</b>	
<b>Credits</b>	4
<b>Contact Hours</b>	4
<b>Liberal Arts</b>	<input checked="" type="checkbox"/> Yes <input type="checkbox"/> No
<b>Course Attribute (e.g. Writing Intensive, etc)</b>	
<b>Course Applicability</b>	<input checked="" type="checkbox"/> Major <input type="checkbox"/> Gen Ed Required <input type="checkbox"/> Gen Ed - Flexible <input type="checkbox"/> Gen Ed - College <input type="checkbox"/> English Composition <input type="checkbox"/> World Cultures <input type="checkbox"/> Speech <input type="checkbox"/> Mathematics <input type="checkbox"/> US Experience in its Diversity <input type="checkbox"/> Interdisciplinary <input type="checkbox"/> Science <input type="checkbox"/> Creative Expression <input checked="" type="checkbox"/> Advanced Liberal Arts <input type="checkbox"/> Individual and Society <input type="checkbox"/> Scientific World
<b>Effective Term</b>	

**Rationale** This course provides important basics for understanding semiconductor physics for students. The course educates students about the relevant area of physics itself as well as applications in actual devices. This course will be required for the Quantum Technology Track offered by the Physics Department. Also, this course can be designated as a free elective for Chemistry, Computer Science, and Engineering Programs.