### Chemical Physics (CPHY)

**CPHY 60199  THESIS I  2-6 Credit Hours**
Thesis students must register for a total of 6 hours, 2-6 hours in a single semester or distributed over two semesters if desired.

**Prerequisite:** Approval of adviser and graduate standing.

**Schedule Type:** Masters Thesis

**Contact Hours:** 2-6 other

**Grade Mode:** Satisfactory/Unsatisfactory-IP

**CPHY 60299  THESIS II  2 Credit Hours**
Thesis students must continually register each semester until all degree requirements are met.

**Prerequisite:** CPHY 60199 and graduate standing.

**Schedule Type:** Masters Thesis

**Contact Hours:** 2 other

**Grade Mode:** Satisfactory/Unsatisfactory-IP

**CPHY 60498  RESEARCH  1-15 Credit Hours**
(Repealtable for credit) Research or individual investigation. Credits earned may be applied toward meeting degree requirements if approved.

**Prerequisite:** Permission and graduate standing.

**Schedule Type:** Research

**Contact Hours:** 3 other

**Grade Mode:** Standard Letter-S/U

**CPHY 62241  SOFT MATTER  3 Credit Hours**
(Cross-listed with CPHY 72241) Lectures on soft materials, including binary fluid mixtures, polymers, colloids, thermotropic and lyotropic liquid crystals. Structures, defects, and textures of phases with orientational and partial translational order. Dynamics of phase transitions.

**Prerequisite:** Graduate standing.

**Schedule Type:** Lecture

**Contact Hours:** 3 lecture

**Grade Mode:** Standard Letter

**CPHY 62242  CHARACTERIZATION OF SOFT MATERIALS  4 Credit Hours**
(Cross-listed with CPHY 72242) Basic techniques in characterization using X-ray scattering, neutron scattering, light scattering, NMR, optical microscopy, scanning electron microscopy, transmission electron and tunneling electron microscopy and ellipsometry. Laboratory measurements, error analysis, cell fabrication.

**Prerequisite:** graduate standing.

**Schedule Type:** Combined Lecture and Lab

**Contact Hours:** 2 lecture, 2 lab

**Grade Mode:** Standard Letter

**CPHY 62245  FUNDAMENTALS OF LIQUID CRYSTAL SCIENCE  4 Credit Hours**
Basic liquid crystals structures and their main physical properties, such as visco-elastic, electric, magnetic and optical properties except the nature of their phase transitions. Also discussed is their interactions with surfaces and the structural defects that they can form.

**Prerequisite:** graduate standing.

**Schedule Type:** Lecture

**Contact Hours:** 4 lecture

**Grade Mode:** Standard Letter

**CPHY 62248  LIQUID CRYSTAL OPTICS AND PHOTONICS  4 Credit Hours**
(Cross-listed with CPHY 72248) Optics of cholesterics, liquid crystalline photonic bandgap materials, nonlinear optics of liquid crystals; optomechanical effects in liquid crystal elastomers.

**Prerequisite:** graduate standing.

**Schedule Type:** Lecture

**Contact Hours:** 4 lecture

**Grade Mode:** Standard Letter

**CPHY 62249  LABVIEW FOR DATA ACQUISITION AND INSTRUMENT CONTROL  1 Credit Hour**
(Cross-listed with CPHY 72249) Introduction to laboratory data acquisition and instrument control using LabView Software.

**Prerequisite:** graduate standing.

**Schedule Type:** Lecture

**Contact Hours:** 1 lecture

**Grade Mode:** Standard Letter

**CPHY 62335  ADVANCED LIQUID CRYSTALLINE AND POLYMERIC MATERIALS  4 Credit Hours**
(Cross-listed with CPHY 72335) Liquid crystals and polymers are soft matters of two important disciplines of science and technology. They both have a similar history and are rich in physical and optical properties useful for fundamental and applied research. This course introduces students to recent advances in liquid crystals and polymers with emphasis on structure-property relationships, physical and optical properties, and their applications.

**Prerequisite:** doctoral standing.

**Schedule Type:** Combined Lecture and Lab

**Contact Hours:** 3 lecture, 2 lab

**Grade Mode:** Standard Letter

**CPHY 62450  LIQUID CRYSTAL OPTICS I: THEORY  2 Credit Hours**
(Slashed with CPHY 72450) Provides an introduction to optical phenomena with an emphasis on liquid crystals from geometrical optics to Maxwell’s equations. Basic principles are used to analyze and solve optics problems arising in liquid crystal engineering.

**Prerequisite:** Graduate standing.

**Schedule Type:** Lecture

**Contact Hours:** 2 lecture

**Grade Mode:** Standard Letter

**CPHY 62452  LIQUID CRYSTAL OPTICS II: OPTICAL SYSTEMS  2 Credit Hours**
(Slashed with CPHY 72452) Focuses on the study of practical optical systems with an emphasis on liquid crystals. Starting with the understanding of basic optical components such as lenses, mirrors, filters and polarizers, students study the principles of optical system design. Practical concepts and techniques for the implementation of optical instruments and displays will be mastered through lectures and lab work.

**Prerequisite:** CPHY 62450; and graduate standing.

**Schedule Type:** Combined Lecture and Lab

**Contact Hours:** 1 lecture, 2 lab

**Grade Mode:** Standard Letter
CPHY 62454 LIQUID CRYSTAL OPTICS III: APPLICATIONS 1 Credit Hour
(Slashed with CPHY 72454) Focuses on the study of practical optical systems for liquid crystal optical devices. Fundamental optical characteristics of liquid crystal displays and the standard methods of characterization are studied in the lab.
Prerequisite: CPHY 62450; and graduate standing.
Corequisite: CPHY 62452.
Schedule Type: Laboratory
Contact Hours: 2 lecture
Grade Mode: Standard Letter

CPHY 62460 LIQUID CRYSTAL MATERIALS SCIENCE 2 Credit Hours
(Slashed with CPHY 72460) Familiarizes students with the basic, underlying chemical concepts in liquid crystal science. These concepts include molecular structures and properties of liquid crystal molecules, miscibility rules and micro-segregation of chemically incompatible molecular segments, physical and electronic properties of aromatic compounds including heterocycles and fluorinated aromatics, properties of aliphatic and perfluorinated hydrocarbons, unsaturation, and chirality. Other aspects that will be covered in later sections of this course relate to auxiliary and novel materials used in liquid crystal devices such as polymers, carbon nanomaterials, metal and semiconductor nanoparticles, and photo-responsive organic materials.
Prerequisite: Graduate standing.
Schedule Type: Lecture
Contact Hours: 2 lecture
Grade Mode: Standard Letter

CPHY 62462 LIQUID CRYSTAL SCIENCE: PHYSICAL PROPERTIES 3 Credit Hours
(Slashed with CPHY 72462) Basics of liquid crystal defects and their behavior in magnetic and electric fields. Pre- or
Prerequisite: Graduate standing.
Corequisite: CPHY 62460.
Schedule Type: Lecture
Contact Hours: 3 lecture
Grade Mode: Standard Letter

CPHY 62643 LIQUID CRYSTAL APPLICATIONS 4 Credit Hours
(Cross-listed with CPHY 72643) Apply knowledge of liquid crystals and optics to the design of liquid crystal electro-optical devices. Emphasis is on modeling of devices and the use of that modeling to optimize device characteristics. Several particular device designs are considered to familiarize the student with the state of the art in liquid crystal displays and other electro-optical applications of liquid crystals and to prepare them to advance the art in future designs.
Prerequisite: graduate standing.
Schedule Type: Lecture
Contact Hours: 4 lecture
Grade Mode: Standard Letter

CPHY 62647 STRUCTURED FLUIDS 3 Credit Hours
(Cross-listed with CPHY 72647) The basics of fluids having internal structures, such as long range orientational order andor one and two dimensional positional order. Materials include thermotropic smectic, lamellar lyotropic and columnar liquid crystals, soap films, fluid foams, fluid fibers and Langmuir monolayers.
Prerequisite: graduate standing.
Schedule Type: Lecture
Contact Hours: 3 lecture
Grade Mode: Standard Letter

CPHY 62650 COMPUTATIONAL MATERIALS SCIENCE 3 Credit Hours
(Cross-listed with CPHY 72650) Materials modeling at the classical (i.e. non-quantum) level. Monte Carlo methods; molecular dynamics simulation; mesoscale models; numerical methods; case studies.
Prerequisite: graduate standing.
Schedule Type: Lecture
Contact Hours: 3 lecture
Grade Mode: Standard Letter

CPHY 62651 NANOBIOTECHNOLOGY 3 Credit Hours
(Cross-listed with CPHY 72651) This interdisciplinary course presents the concepts, principles and the state-of-the-arts of nanotechnologies and their applications in biological and biomedical science and engineering. Focus is on the fundamental physical principles and engineering technologies of device miniaturization and system integration for bioapplications.
Prerequisite: graduate standing.
Schedule Type: Lecture
Contact Hours: 3 lecture
Grade Mode: Standard Letter

CPHY 64491 SEMINAR: LIQUID CRYSTALS 1 Credit Hour
(Repeatable for credit) (Cross-listed with CPHY 74491) Discussion of current literature or original research in liquid crystals. Participation by students faculty and guests.
Prerequisite: Special approval and graduate standing.
Schedule Type: Seminar
Contact Hours: 1 other
Grade Mode: Satisfactory/Unsatisfactory

CPHY 64495 SPECIAL TOPICS IN CHEMICAL PHYSICS 1-3 Credit Hours
(Repeatable for credit) (Cross-listed with CPHY 74495) Topic to be announced when scheduled.
Prerequisite: Special approval and graduate standing.
Schedule Type: Lecture
Contact Hours: 1-3 lecture
Grade Mode: Standard Letter
CPHY 65002 LIQUID CRYSTAL DEVICE ENGINEERING I 2 Credit Hours
(Slashed with CPHY 75002) Introduction to liquid crystal device technology including a hands-on investigation of the component parts of LCDs and how the devices function. Covers the basics of liquid crystals as related to LC technology; examples of current LC technology with an emphasis on the fundamental science behind the technology and hands-on characterization of it; and the consideration of next generation LC device technology, such as 3D displays and optical devices.
Prerequisite: Graduate standing.
Schedule Type: Lecture
Contact Hours: 2 lecture
Grade Mode: Standard Letter

CPHY 65004 LIQUID CRYSTAL DEVICE ENGINEERING II 3 Credit Hours
(Slashed with CPHY 75004) Provides an introduction to LC device design including a hands on look at the designs of devices, the basic modeling tools used in 1D and 2D devices, and the consideration of the modeling and effect of defects in LC devices.
Prerequisite: CPHY 65002; and graduate standing.
Schedule Type: Lecture
Contact Hours: 3 lecture
Grade Mode: Standard Letter

CPHY 65006 LIQUID CRYSTAL DEVICE PROTOTYPING 2 Credit Hours
(Slashed with CPHY 75006) Liquid crystal device prototyping; introduction to liquid crystal device manufacturing methods.
Prerequisite: Graduate standing.
Schedule Type: Combined Lecture and Lab
Contact Hours: 1 lecture, 2 lab
Grade Mode: Standard Letter

CPHY 65008 LIQUID CRYSTAL DEVICE CONSTRUCTION 1 Credit Hour
(Slashed with CPHY 75008) Students acquire the knowledge and experience in basic techniques and procedures for the construction of liquid crystal cells. Based on the cleanroom techniques, ITO glass handling, film deposition, surface alignment treatment and cell assembly experienced, students are prepared for successive lab courses and the capstone project.
Prerequisite: Graduate standing.
Schedule Type: Laboratory
Contact Hours: 2 lab
Grade Mode: Standard Letter

CPHY 65010 LIQUID CRYSTAL CHARACTERIZATION 2 Credit Hours
(Slashed with CPHY 75010) Focuses on experimental techniques which are used to characterize liquid crystals and liquid crystal devices. The students will learn principles and uses of characterization and test equipment to measure physical properties of liquid crystal materials and test the performance of liquid crystal cells.
Prerequisite: Graduate standing.
Schedule Type: Combined Lecture and Lab
Contact Hours: 1 lecture, 2 lab
Grade Mode: Standard Letter

CPHY 65012 LIQUID CRYSTAL DEVICE TESTING 2 Credit Hours
(Slashed with CPHY 75012) Focuses on experimental techniques which are used to test liquid crystal devices. Students will use advanced equipment in the Liquid Crystal Institute Clean Room Facility to measure the response and evaluate the performance of liquid crystal devices.
Prerequisite: Graduate standing.
Schedule Type: Combined Lecture and Lab
Contact Hours: 1 lecture, 2 lab
Grade Mode: Standard Letter

CPHY 65020 LIQUID CRYSTAL ANALOG ELECTRONICS 2 Credit Hours
(Slashed with CPHY 75020) Familiarizes students with both theory and laboratory experiments on analog electronics for liquid crystal devices. Key topics are circuit analysis, operational amplifiers and data acquisition, analysis and equipment control using LabView.
Prerequisite: Graduate standing.
Schedule Type: Combined Lecture and Lab
Contact Hours: 1 lecture, 2 lab
Grade Mode: Standard Letter

CPHY 65022 LIQUID CRYSTAL DIGITAL ELECTRONICS 2 Credit Hours
(Slashed with CPHY 75022) Familiarizes students with both theory and laboratory experiments on digital electronics for liquid crystal displays. Key topics are AD, DA and logic circuits, microcontrollers and digital communications.
Prerequisite: CPHY 65020; and graduate standing.
Schedule Type: Combined Lecture and Lab
Contact Hours: 1 lecture, 2 lab
Grade Mode: Standard Letter

CPHY 65032 SCIENTIFIC COMMUNICATION 1 Credit Hour
(Slashed with CPHY 75032) Catalog Description: Course aims to help graduate students in STEM fields improve their skills in scientific writing and presentations. Activities include a mock panel review of scientific proposals. Each student will produce a final paper which could serve as the introductory chapter of a thesis or dissertation. Prerequisites: Graduate Standing
Schedule Type: Lecture
Contact Hours: 1 lecture
Grade Mode: Standard Letter

CPHY 65098 MASTER'S PROJECT: ENGINEERING APPLICATIONS OF LIQUID CRYSTALS 6 Credit Hours
Offers an opportunity for students to carry out a project that aims to develop a liquid crystal device for a particular application, experiencing the complete development process from the field analysis, idea generation, concept design, feasibility study, implementation and testing.
Prerequisite: CPHY 62460 or CPHY 72460; and CPHY 62462 or CPHY 72462; and CPHY 62450 or CPHY 72450; and CPHY 62452 or CPHY 72452; and CPHY 62454 or CPHY 72454; and CPHY 65008 or CPHY 75008; and CPHY 65022 or CPHY 75022; and graduate standing.
Schedule Type: Master's Project
Contact Hours: 6 other
Grade Mode: Standard Letter-IP
CPHY 72241  SOFT MATTER  3 Credit Hours
(Cross-listed with CPHY 62241) Lectures on soft materials, including binar y fluid mixtures, polymers, colloids, thermotropic and lyotropic liquid crystals. Structures, defects, and textures of phases with orientational and partial translational order. Dynamics of phase transitions.
Prerequisite: Doctoral standing.
Schedule Type: Lecture
Contact Hours: 3 lecture
Grade Mode: Standard Letter

CPHY 72242  CHARACTERIZATION OF SOFT MATERIALS  4 Credit Hours
(Cross-listed with CPHY 62242) Basic techniques in characterization using X-ray scattering, neutron scattering, light scattering, NMR, optical microscopy, scanning electron microscopy, transmission electron and tunneling electron microscopy and ellipsometry. Laboratory measurements, error analysis, cell fabrication.
Prerequisite: doctoral standing.
Schedule Type: Combined Lecture and Lab
Contact Hours: 2 lecture, 2 lab
Grade Mode: Standard Letter

CPHY 72245  FUNDAMENTALS OF LIQUID CRYSTAL SCIENCE  4 Credit Hours
Basic liquid crystals structures and their main physical properties, such as visco-elastic, electric, magnetic and optical properties, except the nature of their phase transitions. It also discusses their interactions with surfaces and the structural defects that they can form.
Prerequisite: doctoral standing.
Schedule Type: Lecture
Contact Hours: 4 lecture
Grade Mode: Standard Letter

CPHY 72248  LIQUID CRYSTAL OPTICS AND PHOTONICS  4 Credit Hours
(Cross-listed with CPHY 62248) Optics of cholesterics, liquid crystalline photonic bandgap materials, nonlinear optics of liquid crystals; optomechanical effects in liquid crystal elastomers.
Prerequisite: Doctoral standing.
Schedule Type: Lecture
Contact Hours: 4 lecture
Grade Mode: Standard Letter

CPHY 72249  LABVIEW FOR DATA ACQUISITION AND INSTRUMENT CONTROL  1 Credit Hour
(Cross-listed with CPHY 62249) Introduction to laboratory data acquisition and instrument control using Labview software.
Prerequisite: doctoral standing.
Schedule Type: Lecture
Contact Hours: 1 lecture
Grade Mode: Satisfactory/Unsatisfactory

CPHY 72335  ADVANCED LIQUID CRYSTALLINE AND POLYMERIC MATERIALS  4 Credit Hours
(Cross-listed with CPHY 62335) Liquid crystals and polymers are soft matters of two important disciplines of science and technology. They both have a similar history and are rich in physical and optical properties useful for fundamental and applied research. This course introduces students to recent advances in liquid crystals and polymers with emphasis on structure-property relationships, physical and optical properties, and their applications.
Prerequisite: doctoral standing.
Schedule Type: Combined Lecture and Lab
Contact Hours: 3 lecture, 2 lab
Grade Mode: Standard Letter

CPHY 72460  LIQUID CRYSTAL MATERIALS SCIENCE  2 Credit Hours
(Slashed with CPHY 62460) Familiarizes students with the basic, underlying chemical concepts in liquid crystal science. These concepts include molecular structures and properties of liquid crystal molecules, miscibility rules and micro-segregation of chemically incompatible molecular segments, physical and electronic properties of aromatic compounds including heterocycles and fluorinated aromatics, properties of aliphatic and perfluorinated hydrocarbons, unsaturation, and chirality. Other aspects that will be covered in later sections of this course relate to auxiliary and novel materials used in liquid crystal devices such as polymers, carbon nanomaterials, metal and semiconductor nanoparticles, and photo-responsive organic materials.
Prerequisite: Doctoral standing.
Schedule Type: Lecture
Contact Hours: 2 lecture
Grade Mode: Standard Letter

CPHY 72462  LIQUID CRYSTAL SCIENCE: PHYSICAL PROPERTIES  3 Credit Hours
(Slashed with CPHY 62462) Basics of liquid crystal defects and their behavior in magnetic and electric fields. Pre- or
Prerequisite: Doctoral standing.
Corequisite: CPHY 72460.
Schedule Type: Lecture
Contact Hours: 3 lecture
Grade Mode: Standard Letter
CPHY 72640  LIQUID CRYSTAL, POLYMER AND COLLOID COMPOSITES  4 Credit Hours
(Cross-listed with CPHY 62640) Interdisciplinary science of systems consisting of liquid crystal, polymer and colloid. Statistical physics of composite systems; mixing free energy, phase separation principle, phase diagrams and phase separation dynamics. States, structures and free energies of liquid crystal, polymer and colloidal systems. Polymer dispersed liquid crystals (PDLCs), polymer stabilized liquid crystals (PSLCs) and their applications. Laboratory experiments on composite systems and fabrication of PDLC and PSLC light shutters.
Prerequisite: doctoral standing.
Schedule Type: Combined Lecture and Lab
Contact Hours: 3 lecture, 1 lab
Grade Mode: Standard Letter

CPHY 72643  LIQUID CRYSTAL APPLICATIONS  4 Credit Hours
(Cross-listed with CPHY 62643) Apply knowledge of liquid crystals and optics to the design of liquid crystal electro-optical devices. Emphasis is on modeling of devices and the use of that modeling to optimize device characteristics. Several particular device designs are considered to familiarize the student with the state of the art in liquid crystal displays and other electro-optical applications of liquid crystals and to prepare them to advance the art in future designs.
Prerequisite: doctoral standing.
Schedule Type: Lecture
Contact Hours: 4 lecture
Grade Mode: Standard Letter

CPHY 72647  STRUCTURED FLUIDS  3 Credit Hours
(Cross-listed with CPHY 62647) The basics of fluids having internal structures, such as long range orientational order and one and two dimensional positional order. Such materials include thermotropic smectic, lamellar lyotropic and columnar liquid crystals, soap films, fluid foams, fluid fibers and Langmuir monolayers.
Prerequisite: doctoral standing.
Schedule Type: Lecture
Contact Hours: 3 lecture
Grade Mode: Standard Letter

CPHY 72650  COMPUTATIONAL MATERIALS SCIENCE  3 Credit Hours
(Cross-listed with CPHY 62650) Materials modeling at the classical (i.e. non-quantum) level. Monte Carlo methods; molecular dynamics simulation; mesoscale models; numerical methods; case studies.
Prerequisite: doctoral standing.
Schedule Type: Lecture
Contact Hours: 3 lecture
Grade Mode: Standard Letter

CPHY 72651  NANOBIO TECHNOLOGY  3 Credit Hours
(Cross-listed with CPHY 62651) This interdisciplinary course presents the concepts, principles and the state-of-the-arts of nanotechnologies and their applications in biological and biomedical science and engineering. Focus is on the fundamental physical principles and engineering technologies of device miniaturization and system integration for bioapplications.
Prerequisite: doctoral standing.
Schedule Type: Lecture
Contact Hours: 3 lecture
Grade Mode: Standard Letter

CPHY 74491  SEMINAR: LIQUID CRYSTALS  1 Credit Hour
(Repeatable for credit) (Cross-listed with CPHY 64491) Discussion of current literature or original research in liquid crystals. Participation by students, faculty and guests.
Prerequisite: Special approval and doctoral standing.
Schedule Type: Seminar
Contact Hours: 1 other
Grade Mode: Satisfactory/Unsatisfactory

CPHY 74495  SPECIAL TOPICS IN CHEMICAL PHYSICS  1-3 Credit Hours
(Repeatable for credit) (Cross-listed with CPHY 64495) Topic to be announced when scheduled.
Prerequisite: Special approval and doctoral standing.
Schedule Type: Lecture
Contact Hours: 1-3 lecture
Grade Mode: Standard Letter

CPHY 75002  LIQUID CRYSTAL DEVICE ENGINEERING I  2 Credit Hours
(Slashed with CPHY 65002) Introduction to liquid crystal device technology including a hands-on investigation of the component parts of LCDs and how the devices function. Covers the basics of liquid crystals as related to LC technology; examples of current LC technology with an emphasis on the fundamental science behind the technology and hands-on characterization of it; and the consideration of next generation LC device technology, such as 3D displays and optical devices.
Prerequisite: Doctoral standing.
Schedule Type: Lecture
Contact Hours: 2 lecture
Grade Mode: Standard Letter

CPHY 75004  LIQUID CRYSTAL DEVICE ENGINEERING II  3 Credit Hours
Provides an introduction to LC device design including a hands-on look at the designs of devices, the basic modeling tools used in 1D and 2D devices, and the consideration of the modeling and effect of defects in LC devices.
Prerequisite: CPHY 75002; and doctoral standing.
Schedule Type: Lecture
Contact Hours: 3 lecture
Grade Mode: Standard Letter

CPHY 75006  LIQUID CRYSTAL DEVICE PROTOTYPING  2 Credit Hours
(Slashed with CPHY 65006) Liquid crystal device prototyping; an introduction to liquid crystal device manufacturing methods.
Prerequisite: Doctoral standing.
Schedule Type: Combined Lecture and Lab
Contact Hours: 1 lecture, 2 lab
Grade Mode: Standard Letter

CPHY 75008  LIQUID CRYSTAL DEVICE CONSTRUCTION  1 Credit Hour
(Slashed with CPHY 65008) Students acquire the knowledge and experience in basic techniques and procedures for the construction of liquid crystal cells. Based on the cleanroom techniques, ITO glass handling, film deposition, surface alignment treatment and cell assembly experienced, students are prepared for successive lab courses and the capstone project.
Prerequisite: Doctoral standing.
Schedule Type: Laboratory
Contact Hours: 2 lab
Grade Mode: Standard Letter
**CPHY 75010** LIQUID CRYSTAL CHARACTERIZATION 2 Credit Hours  
(Slashed with CPHY 65010) Focuses on experimental techniques which are used to characterize liquid crystals and liquid crystal devices. The students will learn principles and uses of characterization and test equipment to measure physical properties of liquid crystal materials and test the performance of liquid crystal cells.  
**Prerequisite:** Doctoral standing.  
**Schedule Type:** Combined Lecture and Lab  
**Contact Hours:** 1 lecture, 2 lab  
**Grade Mode:** Standard Letter  

**CPHY 75012** LIQUID CRYSTAL DEVICE TESTING 2 Credit Hours  
(Slashed with CPHY 65012) Focuses on experimental techniques which are used to test liquid crystal devices. Students will use advanced equipment in the Liquid Crystal Institute Clean Room Facility to measure the response and evaluate the performance of liquid crystal devices.  
**Prerequisite:** Doctoral standing.  
**Schedule Type:** Combined Lecture and Lab  
**Contact Hours:** 1 lecture, 2 lab  
**Grade Mode:** Standard Letter  

**CPHY 75020** LIQUID CRYSTAL ANALOG ELECTRONICS 2 Credit Hours  
(Slashed with CPHY 65020) Familiarizes students with both theory and laboratory experiments on analog electronics for liquid crystal devices. Key topics are circuit analysis, operational amplifiers and data acquisition, analysis and equipment control using LabView.  
**Prerequisite:** Doctoral standing.  
**Schedule Type:** Combined Lecture and Lab  
**Contact Hours:** 1 lecture, 2 lab  
**Grade Mode:** Standard Letter  

**CPHY 75022** LIQUID CRYSTAL DIGITAL ELECTRONICS 2 Credit Hours  
(Slashed with CPHY 65022) Familiarizes students with both the theory and laboratory experiments on digital electronics for liquid crystal displays. Key topics are AD, DA and logic circuits, microcontrollers and digital communications.  
**Prerequisite:** CPHY 75020, and doctoral standing.  
**Schedule Type:** Combined Lecture and Lab  
**Contact Hours:** 1 lecture, 2 lab  
**Grade Mode:** Standard Letter  

**CPHY 75032** SCIENTIFIC COMMUNICATION 1 Credit Hour  
(Slashed with CPHY 75032): Course aims to help graduate students in STEM fields improve their skills in scientific writing and presentations. Activities include a mock panel review of scientific proposals. Each student will produce a final paper which could serve as the introductory chapter of a thesis or dissertation. Prerequisites: Doctoral standing  
**Schedule Type:** Lecture  
**Contact Hours:** 1 lecture  
**Grade Mode:** Standard Letter  

**CPHY 80199** DISSERTATION I 15 Credit Hours  
(Repeatable for credit) Doctoral dissertation for which registration in at least two semesters is required, first of which will be semester in which dissertation work is begun, and continuing until the completion of 30 hours.  
**Prerequisite:** Special approval and doctoral standing.  
**Schedule Type:** Dissertation  
**Contact Hours:** 15 other  
**Grade Mode:** Satisfactory/Unsatisfactory-IP  

**CPHY 80299** DISSERTATION II 15 Credit Hours  
(Repeatable for credit) Continuing registration required of doctoral students who have completed the initial 30 hours of dissertation and continuing until all degree requirements are met. Doctoral standing.  
**Prerequisite:** Completion of 30 hours of CPHY 80199.  
**Schedule Type:** Dissertation  
**Contact Hours:** 15 other  
**Grade Mode:** Satisfactory/Unsatisfactory-IP  

**CPHY 80498** RESEARCH 1-15 Credit Hours  
(Repeatable for credit) Research or individual investigation for doctoral student who has not yet passed candidacy exam. Credit earned may be applied toward degree.  
**Prerequisite:** Doctoral standing.  
**Schedule Type:** Research  
**Contact Hours:** 1-15 other  
**Grade Mode:** Satisfactory/Unsatisfactory-IP