

## CHEMICAL PHYSICS INTERDISCIPLINARY PROGRAM

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The Chemical Physics Interdisciplinary Program offers graduate courses and research leading to the Master of Science and Doctor of Philosophy degrees. The program involves the participation of the departments of Chemistry, Physics, Mathematics and Computer Science, as well as the Liquid Crystal Institute®, and offers concentrations for the master's and doctoral degrees in the following areas:

#### Optoelectronics

This area of concentration is designed for the applied physicist, chemist or engineer who desires to study materials for their application in information display and related devices. This unique concentration is designed to take advantage of Kent State University's role as a leading contributor to this technology, and to prepare students for the rapidly developing display and optoelectronics industry. This concentration includes specialized chemical physics courses such as liquid crystal displays and semiconductor devices, along with supporting courses from the Department of Physics. The doctoral candidates in this concentration will investigate a research topic of importance in optoelectronics technology. The research topic could be material-oriented, examining some aspect of a material utilized in a display, or device-oriented, examining the physics of operation of the device.

#### Physical Properties of Liquid Crystals

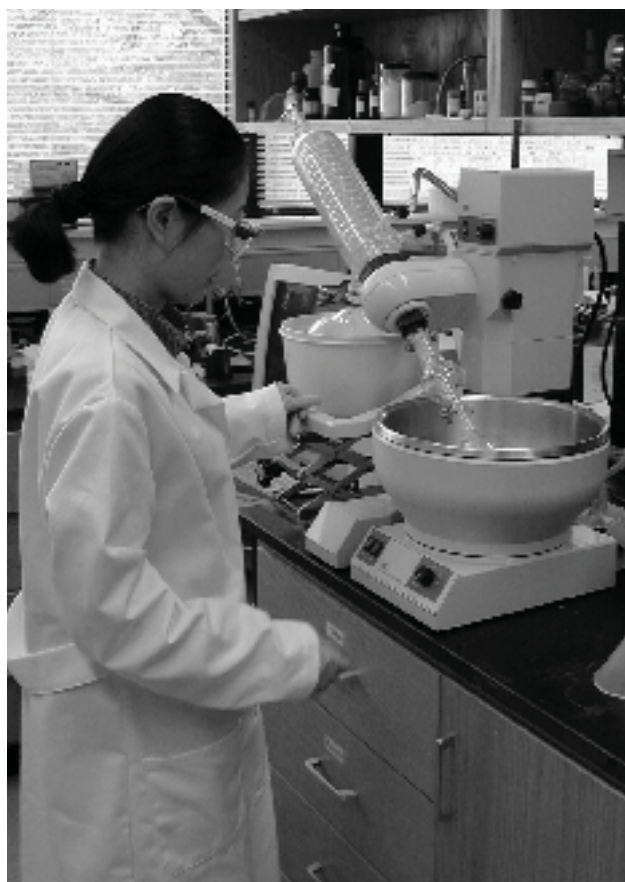
This concentration is intended for students with an interest in the physics of liquid crystalline materials, who desire more training in chemistry and materials science than is offered in the Department of Physics. Students in this concentration can be admitted from a number of undergraduate disciplines, including physics, chemistry, materials science, and chemical physics or engineering. They will pursue advanced training, studying the interaction of liquid crystals with fields and surfaces; structural transitions, instabilities, hydrodynamics, coating preparations and rheology; characterization by linear and nonlinear optics, X-rays, NMR, SEM, tunneling electron and atomic force microscopy, and other techniques. The students will take courses designed to give an in-depth understanding of the unique material properties of these phases. The coursework will prepare the students for dissertation projects that investigate physical properties of timely interest and importance in the advancement of our understanding of liquid crystalline materials.

#### Liquid Crystal Synthesis and Molecular Design

This concentration is designed for the student interested in organic chemistry. The program offers more training in physics and the science of liquid crystalline materials than is traditionally provided in a graduate program in the Department of Chemistry. This concentration is tailored for students with an undergraduate background in chemistry or chemical engineering who wish to pursue graduate training in molecular design and synthesis of new and innovative liquid crystal materials. Under this program students will take several advanced courses offered in the Department of Chemistry and also courses in the Chemical Physics Interdisciplinary Program designed to improve their understanding of molecular properties important in liquid crystallinity and in the physical characterization of these materials. Dissertation work will involve the design and synthesis of new materials.

#### Lyotropic Liquid Crystals and Membranes

This area of concentration is appropriate for science majors who wish to extend their undergraduate education to the science of materials in living systems. This concentration is intended for undergraduate majors in chemistry, physics, chemical engineering and possibly biology, although some



preparatory coursework may be required for the latter. In addition to coursework in biochemistry, this program includes such courses as Lyotropic Liquid Crystals, Micellar Systems and Chemistry of Amphiphiles, which give the students an in-depth understanding of lyotropic liquid crystal materials.

### General Chemical Physics

This is a broad interdisciplinary concentration involving chemistry and physics, not focused on liquid crystals, and employing the techniques of theoretical and experimental physics. Applicants must have at least a "B" average in all undergraduate chemistry and physics courses taken for either a physics or chemistry major. Courses required for admission, in addition to introductory chemistry, are basic organic chemistry, introductory physics, intermediate mechanics, electronics and one semester of differential equations. Applicants lacking some of these requirements may enroll (without graduate credit) in the equivalents during their first year at Kent State University. Only students keenly interested in both chemistry and physics should consider entering this program.

#### GENERAL GUIDELINES OF THE CHEMICAL PHYSICS INTERDISCIPLINARY PROGRAM

The Chemical Physics Interdisciplinary Program follows the general regulations of the College of Arts and Sciences and the Office of Research and Graduate Studies. Together with a faculty advisor, incoming students can determine which concentration will best suit their needs. Exposure to current research and outside speakers is provided through participation in the liquid crystal, chemistry and physics seminar programs.

For more information, visit [www.lci.kent.edu](http://www.lci.kent.edu).

### Master of Science

#### ADMISSION

Because of the interdisciplinary nature of the program, students from a variety of undergraduate disciplines, such as chemistry, physics, chemical physics, materials science and engineering, will be eligible for admission to the Chemical Physics Interdisciplinary Program. Admission will be granted by examination of the student's background on an individual basis.

#### PROGRAM REQUIREMENTS

General requirements for the Master of Science degree at Kent State University have been established by the College of Arts and Sciences and the Office of Research and Graduate Studies. While most students in the Chemical Physics Interdisciplinary Program are expected to work toward the Ph.D. degree, the master's degree program is available. The academic requirement for the Master of Science degree is successful completion of courses from the curriculum and the completion of a master's thesis.

A total of 32 credit hours is required for each concentration in

the master's degree program. For each of the five concentrations, students are required to complete 24-27 credit hours of core courses.

Candidates for the Master of Science degree must register for CPHY 60199, Thesis I, for a total of 6 credits. The thesis for the Master of Science degree will present and interpret results of original research and must be defended before a committee of the Chemical Physics graduate faculty.

The choice of remaining electives must be approved by the student's faculty advisor. Suggested course schedules and lists of recommended electives for each of the following concentrations in the master's degree program can be found in the brochure *Graduate Studies and Research in Chemical Physics at Kent State University*, which is available from the program director's office.

#### Optoelectronics and Physical Properties of Liquid Crystals Concentrations

Required Core Courses:

CHEM	6/70541	.....3
CPHY	6/72241	.....3
CPHY	6/72242	.....2
CPHY	6/72245	.....3
CPHY	6/72250	.....3
PHY	55201	.....3
PHY	55501	.....3
Required Seminar:		
CPHY	6/74491 (2 enrollments)	.....2

#### Liquid Crystal Synthesis and Molecular Design and Lyotropic Liquid Crystals and Membranes Concentrations

Required Core Courses:

CHEM	6/70333	.....3
CHEM	6/70471	.....3
CHEM	6/70472	.....3
CHEM	6/70541	.....3
CPHY	6/72241	.....3
CPHY	6/72242	.....2
CPHY	6/72243	.....3
CPHY	6/72250	.....3
Required Seminar:		
CPHY	6/74491 (2 enrollments)	.....2

#### General Chemical Physics Concentration

Required Core Courses:

CHEM	5/70361	.....2
CHEM	5/70481	.....2
CHEM	6/70541	.....3
PHY	6/75101	.....3
PHY	6/75401	.....4
PHY	6/76402	.....3

and either

PHY	55201	.....3
or		
PHY	6/75203	.....3
and either		
CHEM	6/70542	.....3
or		
PHY	6/76161	.....3

### Doctor of Philosophy

General requirements for the Doctor of Philosophy degree at Kent State University have been established by the College of Arts and Sciences and the Office of Research and Graduate Studies.

#### PROGRAM REQUIREMENTS

For each of the five concentrations, students are required to complete 36 credit hours of core courses and 12 credit hours of electives for the general chemical physics concentration, and 24-27 credit hours of core courses and 30 credit hours of electives for all other concentrations. The choice of electives must be approved by the student's faculty advisor. The elective requirements may be waived depending on previously completed coursework. Suggested course schedules and lists of recommended electives for each of the following concentrations in the Doctor of Philosophy program can be found in the brochure Graduate Studies and Research in Chemical Physics at Kent State University, which is available from the program director's office.

#### COMPUTER LANGUAGE REQUIREMENT

Every successful candidate for the doctoral degree must satisfy a computer language requirement. This requirement can be satisfied by one of the following: (1) Completion of either Scientific Computing (PHY 35402), Introduction to Computer Science (CS 10061) or Computer Analysis of Experimental Measurements (PHY 5/75403) with a grade of "B" or better. Equivalent coursework from the student's previous academic records may satisfy this requirement. (2) Since a student may acquire the necessary literacy to fulfill this requirement through use of computers in carrying out dissertation research, the student's dissertation advisor may certify proficiency for consideration by the program director.

#### CANDIDACY

In addition to satisfying the course and computer language requirements, the student must pass the Chemical Physics Interdisciplinary Program candidacy examination. The examination will cover material in the core courses of the chemical physics program. A student may make two attempts at passing the examination. If the student fails the second attempt, he/she will not be permitted to continue toward the doctoral degree but may complete the requirements for the Master of Science degree. The student's first attempt at candidacy should come following the first year of study in all concentrations except general chemical physics. In exceptional cases, a student may

defer taking the candidacy examination until the beginning of the third year of graduate study.

#### PROSPECTUS AND DISSERTATION

A prospectus of the dissertation research project is required for all Ph.D. candidates. The prospectus is prepared jointly with the student's dissertation advisor. The prospectus must be approved by the members of the student's dissertation committee.

A dissertation presenting and interpreting results of original research is required for the Doctor of Philosophy degree. The areas of research are outlined under the various concentrations. Following acceptance of the dissertation by the dissertation committee, the final degree requirement is the satisfactory completion of the final oral exam (defense of dissertation) before a committee of the graduate Chemical Physics faculty.

#### Optoelectronics Concentration

Required Core Courses:

CPHY	6/72241	.....3
CPHY	6/72242	.....2
CPHY	6/72245	.....3
CPHY	6/72250	.....3
PHY	55201	.....4
PHY	55501	.....3
CPHY	72640	.....3
CPHY	72643	.....3
CPHY	72647	.....3

Required Seminar:

CPHY	6/74491 (4 enrollments)	.....4
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#### Physical Properties of Liquid Crystals Concentrations

Required Core Courses:

CPHY	6/72241	.....3
CPHY	6/72242	.....2
CPHY	6/72245	.....3
CPHY	6/72250	.....3
PHY	55201	.....4
PHY	55501	.....3
CPHY	72647	.....3
CPHY	72640	.....3

Required Seminar:

CPHY	6/74491 (4 enrollments)	.....4
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#### Liquid Crystal Synthesis and Molecular Design Concentration

Required Core Courses:

CHEM	6/70471	.....3
CHEM	6/70472	.....3
CHEM	6/70541	.....3
CPHY	6/72241	.....3
CPHY	6/72242	.....2
CPHY	72245	.....3
or		
CHEM	70571	.....2

and

CHEM	70595	.....1
CPHY	6/72250	.....3
CPHY	72335	.....3

Required Seminar:

CPHY	6/74491 (4 enrollments)	.....4
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### Lytotropic Liquid Crystals and Membranes Concentration

Required Core Courses:

Either		
CHEM	6/70471	.....3
and		
CHEM	6/70472	.....3
or		
CPHY	72647	.....3
and		
CHEM	70571	.....2
and		
CHEM	70595	.....1
CHEM	6/70541	.....3
CPHY	6/72241	.....3
CPHY	6/72242	.....2
CPHY	72245	.....3
CPHY	6/72250	.....3
CPHY	72335	.....3

Required Seminar (4 hours):

CPHY	6/74491	.....4
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### Courses (CPHY)

#### CPHY 60199 THESIS I (2-6)

Thesis students must register for a total of 6 hours, 2-6 hours in a single semester or distributed over two semesters if desired. S/U grading; IP permissible. Prerequisite: Approval of advisor.

#### CPHY 60299 THESIS II (2)

Thesis students must continually register each semester until all degree requirements are met. S/U grading; IP permissible. Prerequisite: CPHY 60199.

#### CPHY 60498 RESEARCH (1-15)

Research or individual investigation. Credits earned may be applied toward meeting degree requirements if approved. Repeat registration permitted. Prerequisite: Permission.

#### CPHY 62241/72241 SOFT MATTER: STRUCTURES, TEXTURES AND DEFECTS (3)

Lecture/laboratory on soft matter systems, such as thermotropic and lyotropic liquid crystals, colloids. Structures, defects and textures of phases with orientational and partial translational order.

#### CPHY 62242/72242 PHYSICAL METHODS OF MATERIALS CHARACTERIZATION (2)

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.

#### CPHY 62243/72243 LYOTROPIC LIQUID CRYSTALS AND MICELLAR SYSTEMS (3)

Properties of lyotropic liquid crystals, polymer solutions and aqueous solutions of amphiphilic compounds. Self-assembly of amphiphilic compounds, formation and properties of micelles, cylinders, bilayers, vesicles and tubules.

#### CPHY 62245/72245 PHYSICAL PROPERTIES OF LIQUID CRYSTALS (3)

Evaluation of physical properties of liquid crystals. Combined laboratory and lecture course on techniques for characterizing important properties of liquid crystals. Prerequisite: CPHY 62250 or permission.

#### CPHY 62250/72250 LIQUID CRYSTAL MATERIALS (3)

Basic statistical physics of liquid crystals, focusing on the effects of orientational order on physical properties. Topics include phase transitions and electric, magnetic and optical response. Prerequisite: B.S. in chemistry or physics.

#### CPHY 64491/74491 SEMINAR: LIQUID CRYSTALS (1)

Discussion of current literature or original research in liquid crystals. Participation by students, faculty and guests. Repeat registration permitted. S/U grading. Prerequisite: Permission.

#### CPHY 64495/74495 SPECIAL TOPICS IN CHEMICAL PHYSICS (1-3)

Topic to be announced when scheduled. Repeat registration permitted. Prerequisite: Permission.

#### CPHY 72248 LIQUID CRYSTAL OPTICS AND PHOTONICS (3)

Optics of cholesterics, liquid crystalline photonic bandgap materials, nonlinear optics of liquid crystals; optomechanical effects in liquid crystal elastomers.

#### CPHY 72249 LABVIEW FOR DATA ACQUISITION AND INSTRUMENT CONTROL (1)

Introduction to laboratory data acquisition and instrument control using LabView.

**CPHY 72335****ADVANCED LIQUID CRYSTALLINE AND POLYMERIC MATERIALS (3)**

Lecture/laboratory on ordered systems and materials, including liquid crystals, liquid crystal polymers, guest-host systems and effects, photochemical interactions of anisotropic systems, materials for liquid crystal alignment.

**CPHY 72415****FLUID MECHANICS AND RHEOLOGY (3)**

Static and dynamic properties of fluids: hydrostatics, Navier-Stokes equations, Newtonian fluids, viscosity, anisotropic liquids and rheology of highly viscous fluids. Prerequisite: B.S. in chemistry or physics.

**CPHY 72418****DEFECTS IN LIQUID CRYSTAL MATERIALS (3)**

Defects in solids and liquid crystals: observation and characterization of defects, elastic properties, defect interactions and movement, and phases with periodic defect structures. Prerequisite: B.S. in chemistry or physics.

**CPHY 72461****NONLINEAR OPTICS OF MATERIALS (3)**

Fundamentals of nonlinear optics of materials: nonlinear polarization and susceptibilities, optical harmonic generation, sum and difference frequency generation, parametric amplifiers and oscillators, and stimulated scattering. Prerequisite: PHYS 4/55501.

**CPHY 72515****CHEMISTRY OF AMPHIPHILES (3)**

Multiphase liquid crystal systems: molecular structure and properties of amphiphiles in water with emphasis on thermodynamics of self-assembly, phase properties of micellar, hexagonal and lamellar systems. Prerequisite: Permission.

**CPHY 72517****MEMBRANE SPECTROSCOPY (2)**

Multiphase liquid crystal systems: spectroscopic techniques to determine structure and molecular dynamics of model and biological membranes with emphasis on magnetic resonance techniques. Prerequisite: Permission.

**CPHY 72640****LIQUID CRYSTAL/POLYMER COMPOSITES (3)**

Multiphase liquid crystal systems: formation and applications; control of physical and electro-optic properties, liquid crystal configuration and surface alignment. Prerequisite: PHYS 6/78401.

**CPHY 72641****LIQUID CRYSTAL SURFACES AND INTERFACES (3)**

Surface tension of liquids and solids, surface structure, Wulff constructions, wetting and roughening, and experimental methods in surface studies. Prerequisite: B.S. in chemistry or physics.

**CPHY 72643****LIQUID CRYSTAL DISPLAYS (3)**

Science of applications of nematic and smectic liquid crystals. Integrates fundamental concepts and modeling of liquid crystals with focus on the design of liquid crystal devices. Prerequisite: CPHY 6/72250.

**CPHY 72645****SEMICONDUCTOR DEVICES (3)**

Introduction to semiconductor device technology, including principles of operation, integrated circuit fabrication techniques and device applications.

**CPHY 72647****STRUCTURED FLUIDS (3)**

The basics of fluids having internal structures, such as long range orientational order and/or 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.

**CPHY 80199****DISSERTATION I (15)**

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. S/U grading; IP permissible. Prerequisite: Admission to candidacy.

**CPHY 80299****DISSERTATION II (1 or 15)**

Continuing registration required of doctoral students who have completed the initial 30 hours of dissertation and continuing until all degree requirements are met. S/U grading; IP permissible. Prerequisite: Completion of 30 hours of CPHY 80199.

**CPHY 80498****RESEARCH (1-15)**

Research or individual investigation for doctoral student who has not yet passed candidacy exam. Credit earned may be applied toward degree. Repeat registration permitted. S/U grading; IP permissible.