Photon Science (3.0 credits)
Course Syllabus – Spring 2021

Courses: **CHEM 4470** and **CHEM 6470**
Instructor: Samer Gozem
E-mail: sgozem@gsu.edu

Office Hours: I am available to meet via Webex. Email me at sgozem@gsu.edu to set up a time to meet as needed.

Teaching Assistant: Jorge Garcia-Alvarez
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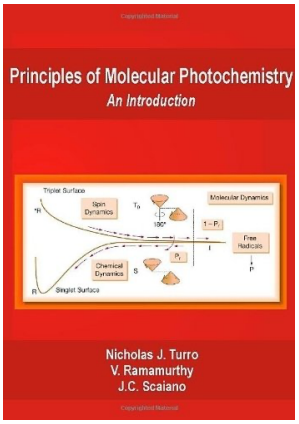
Instruction Mode: Fully online. Lectures are **synchronous** and will be held live MW at 5:30 – 6:45 pm via **Webex**. Everyone is strongly encouraged to attend the live lectures to get an opportunity to participate and ask questions, but the lectures will also be recorded and uploaded to iCollege for those who miss it.

Course Prerequisites: This course relies on chemistry, physics and math concepts from Chem 1212K; Math 2212; Phys 2211K, and Phys 2212K. It is recommended that you have a strong grasp of concepts from these courses.



Textbook: Most of the material in this course uses the following textbook:
"*Principles of Molecular Photochemistry: An Introduction"* by N.J. Turro, V. Ramamurthy, and J.C. Scaiano, 1st Edition, ISBN 978-1891389573.
Use of the textbook is optional. The textbook is very well written and reads almost like a novel. If you typically like to use a textbook to study, I strongly suggest that you get it. There are multiple sources to buy or rent the book (or E-text) online.

Supplemental reading:
For a more in-depth discussion of fluorescence spectroscopy: "*Principles of fluorescence spectroscopy*" by Joseph R Lakowicz, 3rd Edition, Springer US, 2006, ISBN 978-1-4899-7880-6.

For a solid theoretical insight into photochemistry: *"Electronic Aspects of Organic Photochemistry"* by Joseph Michl and Vlasta Bonačić-Koutecký.

For practical details regarding organic photochemistry (including instrumentation, experimental techniques, and numerical data): "The *CRC Handbook of Organic Photochemistry*."

Some of the organic photochemistry lectures I use are derived from "*Organic Chemistry: Theory, Reactivity and Mechanisms in Modern Synthesis*" by Pierre Vogel and Kendall N. Houk.

For a more in-depth understanding of molecular symmetry: "Symmetry and Spectroscopy: An Introduction to Vibrational and Electronic Spectroscopy" by Daniel C. Harris and Micheal D. Bertolucci.

Discussion Forums: For each module, there will be a discussion forum for questions and answers about lectures and assignments. All students can either post questions or reply to questions. However, please do not give direct answers to assignment questions.

Course Description: Photon Sciences is a 3-credit semester course that discusses events occurring in molecular systems following the absorption of light. The first few lectures will introduce some essential background concepts. Next, we will discuss how light absorption is accompanied by changes in the molecular electronic and nuclear structures (**photophysics**). We will then discuss how such photophysical processes can sometimes lead to molecular transformations (**photochemistry**). Finally, we will explain photochemistry that occurs in biological systems such as proteins and DNA (**photobiology**).

Course Objectives: Understand the various processes that can occur upon exciting a molecule with light.

Assignments: For each module, there will typically be one required assignment. The assignment will be available on iCollege soon after the start of the module and will typically be due two weeks after the start of each module.

Project: Students will be assigned projects requiring them to apply what they learned from the photophysics and photochemistry sections of the class to discuss a problem related to photobiology. Students have the opportunity to discuss their projects with the instructor beforehand and suggest something relevant to their academic/research interests, otherwise students will be assigned a random project. All students will write a short report for their project. In addition, Chem 6470 students will also present/discuss what they learned in class. The project is worth 15% of the course grade (counted as part of the assignments grade).

Project reports need to be concise, clearly written, and referenced. and should be **at most** 1000 words (figure captions and references do not count towards word count). Reports will be assessed based on the student's ability to discuss the photophysics or photochemistry of a biological system using concepts learned in this class and referencing appropriate chemical literature. The report is due on April 12th, 2021.

Chem 6470 students will also be asked to present their project towards the end of the semester to share what they learned with the rest of the class. The presentations will take place during module 6.

Some questions that students may address during the report. Those are just examples of questions to consider as you search literature on your topic. You are by no means restricted to those questions:

- If an absorption/fluorescence spectrum is known for your system, include it in the report and comment about it.
- Is the character of the lowest excited state(s) known? (e.g., pi-pi*, n-pi*, singlet, triplet, etc.)
- What happens to this system when it absorbs light? Are the photophysical or photochemical properties known?
- Have quantum yields been reported? Does this system undergo only one process or competing processes?
- If there is a photochemical reaction, is the mechanism known? Does it go through a ground state intermediate, excited state intermediate, or directly via a funnel?
- Have there been any discussions in literature about interesting solvent effects? Protein mutation effects? Can they be explained using concepts discussed in this course?

When writing the report, remember that GSU students have free access to Grammarly, which provides grammar, spelling, and citation monitoring. I strongly recommend using it:
https://technology.gsu.edu/technology-services/it-services/training-and-learning-resources/grammarly/

Exams: Each module (except module 1) will end with an exam. These exams will be made available Fridays at 12 pm and will remain available until Mondays at 5 pm local Atlanta time. Once you start the exam, however, you have to complete it in one sitting within a set time limit. Exams are open book. You can use the book, notes, calculators, and the internet. Please note, however, that exams will be time-limited and once you answer a question you may not return to it. For a limited time after the exam, you may be given the opportunity to take the exam a second time (after Monday) as an assignment for partial credit.
Each exam will test your knowledge of the corresponding module. There will be no other midterm or final exam.

Grading:
The grade breakdown for this course is as follows:

Module	Participation	Assignment	Exam	Total
1	0	5	0	5
2	1	10	10	21
3	1	10	10	21
4	1	5	5	11
5	1	10	10	21
6	1	15 (project)	10	26
Total	5	55	45	**105**

The following plus/minus grading system will be used for everyone:

Grade	Points
A+	100+
A	93-100
A-	90-93
B+	87-90
B	80-87
B-	75-80
C+	70-75
C	65-70
C-	60-65
D	50-60
F	< 50

Last day to withdraw is **Tuesday, Mar 2nd, 2021**
The University requires faculty, on a date set by the Provost after the mid-point of the course,
1. to give a WF to all those students who are on their rolls but no longer taking the class, and
2. to report the last day the student attended or turned in an assignment.

Modules and course schedule:

This part of the course syllabus provides a general plan for the course; please note that deviations may be necessary.

Assignments and exams are due at **5:00 pm** on the due date (typically Mondays). If you miss the deadline for an assignment or exam for reasons outside of your control (i.e., emergencies) please contact me as soon as possible.

Module	Topic	Start date	Assignment Due	Exam due	Points
1	Course Introduction	01/11	01/15	N/A	5
2	Background	01/20	02/01	02/08	21
3	Photophysics	02/08	02/22	03/01	21
4	Molecular symmetry	03/01	03/12	03/22	11
5	Photochemistry	03/22	04/05	04/12	21
6	Photobiology	04/12	04/12 (projects)	04/26	26

The following pages will list specific learning outcomes, tasks, and grading scheme for each module.

Module 1 (M1): Introduction to Photon Sciences.

Start date: Monday, January 11th, 2021.
End date: Friday, January 15th, 2021.
Assignment due: Friday, January 15th, 2021.
Exam due: N/A.

Outcomes:
- Become familiar with the course structure on iCollege as well as the course syllabus.
- Define some basic but important terms that will be used throughout this course.

Tasks:
1. Attend or view all M1 lectures.
2. Complete the first assignment by Friday, January 15th.

M1 Grading (5 points total):
5 points For completing assignment 1 on time.

Module 2 (M2): Background: A crash course in qualitative quantum mechanics.

Start date: Wednesday, January 20th, 2021.
Assignment due: Monday, February 1st, 2021
Exam due: Monday, February 8th, 2021

Outcomes:
- Explain the nature and properties of light.
- Define what a wave function is and what information it contains.
- Use the particle in a box model to explain the effect of conjugation on electronic absorption.
- Use the harmonic oscillator model to describe bond vibrations.
- Explain how atomic and molecular structure arise from quantum mechanics.
- Define spin multiplicity.
- Describe bonding in simple diatomic molecules.

Tasks:
1. Attend or view all M2 lectures.
2. Participate during the lectures or through the discussion forum.
3. Complete the M2 assignment and submit by due date.
4. Complete the M2 exam and submit by due date.

M2 Grading (21 points total):
1 point for participation.
10 points for the M2 assignment.
10 points for the M2 exam.

Module 3 (M3): Photophysics.

Start date: Monday, February 8th, 2021.
Assignment due: Monday, February 22nd, 2021
Exam due: Monday, March 1st, 2021

Outcomes:
- Become accustomed to sizes, energies, and timescales of photophysical and photochemical processes.
- Identify and explain the difference between various radiative and non-radiative processes.
- Use a simple approximate wave function model to explain rates and probabilities of photophysical processes.
- Discuss factors that affect singlet and triplet relative energies in molecules.
- Explain the Franck-Condon principle and Franck-Condon factors.
- Qualitatively describe spin-orbit coupling and factors that affect it.
- Define excited-state lifetimes and discuss factors that affect them.

Tasks:
1. Attend or view all M3 lectures.
2. Participate during the lectures or through the discussion forum.
3. Complete the M3 assignment and submit by due date.
4. Complete the M3 exam and submit by due date.

M3 Grading (21 points total):
1 point for participation.
10 points for the M3 assignment.
10 points for the M3 exam.

Module 4 (M4): Application of Group theory to understanding molecular spectroscopy.

Start date: Monday, March 1st, 2021.
Assignment due: Friday, March 12th, 2021
Exam due: Monday, March 22nd, 2021

Outcomes:
- Identify symmetry elements in molecules.
- Categorize molecules into symmetry groups.
- Use the symmetry group of molecules to explain their spectroscopic properties.

Tasks:
1. Attend or view all M4 lectures.
2. Participate during the lectures or through the discussion forum.
3. Complete the M4 assignment and submit by due date.
4. Complete the M4 exam and submit by due date.

M4 Grading (11 points total):
1 point for participation.
5 points for the M3 assignment.
5 points for the M3 exam.

Module 5 (M5): Photochemistry.

Start date: Monday, March 22nd, 2021.
Assignment due: Monday, April 5th, 2021
Exam due: Monday, April 12th, 2021

Outcomes:
- Identify shapes and features of potential energy surfaces associated with different photochemical processes.
- Describe different shapes of potential energy crossings.
- Use the Woodward-Hoffman rules to describe the stereochemistry of thermal and photochemical electrocyclic reactions.
- Describe the mechanism of common photochemical reactions of alkenes, alkynes, carbonyl groups, and aromatic compounds.

Tasks:
1. Attend or view all M5 lectures.
2. Participate during the lectures or through the discussion forum.
3. Complete the M5 assignment and submit by due date.
4. Complete the M5 exam and submit by due date.

M5 Grading (21 points total):
1 point for participation.
10 points for the M5 assignment.
10 points for the M5 exam.

Module 6 (M6): Photobiology.

Start date: Monday, April 12th, 2021.
Written project due: Monday, April 12th, 2021
Exam due: Monday, May 3rd, 2021

Outcomes:

- Understand the photophysics and photochemistry of natural fluorophores, extrinsic fluorophores, fluorescent proteins, bioluminescent proteins, photoreceptors, and/or DNA bases (varies from semester to semester, depending on projects)

Tasks:

1. Attend or view all M6 lectures.
2. Participate during the lectures or through the discussion forum.
3. Complete the M6 written project and submit by the due date.
4. **Chem 6110 only**: Present your M6 project during one of the lectures.
5. Complete the M6 exam and submit by due date.

M6 Grading (26 points total):

1 point for participation.
15 points for the M6 project.
10 points for the M6 exam.

Student Integrity Policy: All assignments and exams must represent the student's individual, unaided efforts. Receiving unauthorized outside information or offering unauthorized information to another student during an assignment or examination is cheating. Any suspected offenses will be referred to the Department of Chemistry and the College of Arts and Sciences for appropriate action. Please refer to GSU's policy on academic dishonesty for more information: https://deanofstudents.gsu.edu/files/2019/07/Academic-Honesty-Policy.pdf

Americans with Disabilities Act: The Americans with Disabilities Act (ADA) is a federal anti-discrimination statute that provides comprehensive civil rights protection for persons with disabilities. Among other things, this legislation requires that all students with disabilities be guaranteed a learning environment that provides for reasonable accommodation of their disabilities. Students who wish to request accommodation for a disability may do so via the Access and Accommodations Center (AACE) at https://access.gsu.edu/. Students may only be accommodated upon issuance of a signed Accommodation Plan by the AACE Center (see: https://access.gsu.edu/testing-services/) and are responsible for providing a copy of that plan to instructors of all classes in which accommodations are sought.

Family Educational Rights and Privacy Act: In keeping with USG and university policy, this course website will make every effort to maintain the privacy and accuracy of your personal information. Specifically, unless otherwise noted, it will not actively share personal information gathered from the site with anyone except university employees whose responsibilities require access to said records. However, some information collected from the site may be subject to the Georgia Open Records Act. This means that while we do not actively share information, in some cases we may be compelled by law to release information gathered from the site. Also, the site will be managed in compliance with the Family Educational Rights and Privacy Act (FERPA), which prohibits the release of education records without student permission. For more details on FERPA, go here.

Course Evaluation: Your constructive assessment of this course plays an indispensable role in shaping education at Georgia State. Upon completing the course, please take time to fill out the online course evaluation.