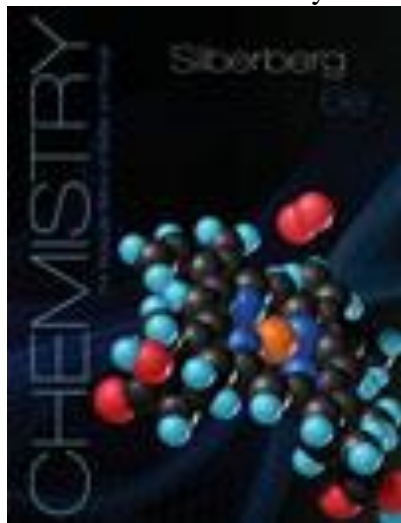


CHM 2045	General Chemistry	Spring 2015
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Class Period	Instructor	Office	Office Hours
MWF 4 th MWF 6 th MWR 10 th	Mitchell	CLB 214 Just upstairs	Office phone 392-0517 jamitchell@chem.ufl.edu
			M W R 7 th , 8 th and 9 th periods Subject to change but will announce

TEXTBOOK: Chemistry: The Molecular Nature of Matter and Change (6th Edition)
by Martin Silberberg (McGraw-Hill)



INFORMATION: CHM 2045 and CHM 2045L constitute the first semester of the two term sequence of General Chemistry, CHM 2045-2045L-2046-2046L. This sequence is suitable for all science and engineering majors.

PREREQUISITES: *Credits: 3; Prereq: MAC 1147 or the equivalent, (Statistics does not count.)*

passing score on ChRA or passing grade in CHM 1025; Coreq: CHM 2045L.

A minimum grade of C is required to progress to CHM 2046. (P) A detailed list of course topics by chapter and course objectives are listed at the end of this syllabus.

Warning!! If you drop your math class and do not have MAC 1147 or the equivalent or higher you **will not** be able to go on to CHM 2046 even if you pass CHM 2045! Read the Guide to Majors catalog. [This means that you must be taking the correct math this term or have it show on your transcript. You will be ejected from CHM 2046 at the start of the next term even if the system allows you to register if you do not have the proper math prerequisite.](#)

Lecture schedule Spring 2015: I will follow this schedule very closely.

Exam dates will not change!!

Section # _____; Discussion day and location _____

Dates	Topics (# of lectures)	Chapters
06 Jan. – 14 Jan.	Introduction and Review: Atoms, Molecules, and Ions	Chap. 1–2
15 Jan. – 23 Jan.	Mass Relations and Stoichiometry	Chap. 3
26 Jan. – 02 Feb.	Aqueous Reactions	Chap. 4
Tuesday, 03 Feb. (8:20-10:20 pm)	Progress Exam 1	Chaps. 1–4
04 Feb. – 09 Feb.	Enthalpy & Calorimetry	Chap. 6
11 Feb.	Atomic Structure	Chap. 7
13 Feb. – 18 Feb.	Electron Configuration and Periodic Trends	Chap. 8
19 Feb. – 25 Feb.	Chemical Bonding Models	Chap. 9
Thursday, 26 Feb. (8:20-10:20 pm)	Progress Exam 2	Chaps. 6–9
09 Mar. – 13 Mar.	Molecular Geometry	Chap. 10
16 Mar. – 20 Mar.	Covalent Bonding Theories	Chap. 11
23 Mar. – 26 Mar.	Gases	Chap. 5
27 Mar. – 01 Apr.	Intermolecular Forces and Liquids and Solids	Chap. 12
Thursday, 02 Apr. (8:20-10:20 pm)	Progress Exam 3	Chaps. 10–12
03 Apr. – 10 Apr.	Solutions	Chap. 13
13 Apr. – 22 Apr.	Chemical Kinetics	Chap. 16
Monday, 27 Apr. (3:00–5:00pm)	Final Exam	Cumulative All chapters!

HOLIDAYS (no classes): 19 Jan MLK Day; Mar 02 – 06 Spring Break

Online Assessment Dates: these assessments are currently scheduled for Wednesday.

Tutorial due dates will be announced.

TIPS: Chemistry is very much a "learn by understanding" subject. Because of this you must work in this course to do well. That means you should read the textbook, work on the website, and do the electronic homework until you understand! Then you should work extra problems (from the book) to test your understanding.

ONLINE ASSESSMENTS: Timed Online Assessments will be posted on most Wednesdays (except Feb. 4 and Mar. 11 - days are subject to change but if so, will be announced). To access the assessments, click on "Assessments" in e-Learning/Sakai. You'll have 60 minutes from the time you open the Assessment to answer the questions therein and you'll have 24 hours (midnight Tuesday to midnight Wednesday) during which you may access the assessment. No makeup assessments will be given for any reason. To accommodate unavoidable conflicts or computer issues that may arise, we only count 10 of the 12 planned Online Assessments toward your grade. It is suggested that you do the assessments early enough in the day to avoid last-minute time or computer issues late at night. If you must be absent for an assessment due to a documented and approved academic or UF athletic conflict, bring the documentation to your instructor beforehand (at least one week prior to the scheduled quiz). Planned or emergency trips home or elsewhere are not approved conflicts.

TUTORIALS AND END-OF-CHAPTER HOMEWORK:

(1) TUTORIALS: A minimum of twelve (12) weekly tutorials will be posted online on e-Learning/Sakai (under the "Assessments" tool). These tutorials will walk students through each chapter's content, pointing out important components of each chapter, and give the students an opportunity to assess their understanding and competence with the material via multiple-choice exam-derived questions that are sequenced in logical order to help facilitate learning. The purpose of the tutorials is to help students to self-identify individual weaknesses and calculational mis-steps so that the students will be aware of these weaknesses before the Progress Exams do this for them. The proper way to approach the tutorials is to first go through them "cold" so that students can self-assess and self-grade themselves on the material; then, students can work with focus and efficiency to address their own individual weaknesses during subsequent attempts. IMPORTANT: Be sure to write down your answers while doing the tutorials so that you will have them at the ready when re-doing the tutorials (if needed). You'll have five (5) attempts to successfully answer the questions. Successful completion of a weekly tutorial will earn the student 10 points. The highest scores of 10 of the 12 (or more) tutorials will count toward your grade. It is up to the student to keep up with the dates during which tutorials are open; failure to at least access the tutorials once before their due dates will result in loss of ability to access the tutorials for the remainder of the semester.

(2) END-OF-CHAPTER PROBLEMS: Suggested problems from the end of each chapter in the textbook will be posted in the Resources folder. Worked-out solutions to all end-of-chapter problems are also found in the Resources folder. Be sure to use this valuable self-assessment resource! I recommend that students use the Tutorials above to self-assess for weaknesses with the material, and to let the results of that self-assessment guide the students as to which End-Of-Chapter problems need to be done. But let me say this: the more problems you do, the more you develop your skills at solving problems and understanding concepts. If success in this course is important to your goals, do not short-change yourself by merely doing the minimum work needed to "get by". Think about it.

DISCUSSION: **First discussion will start the week of January 12th.** Day and location is based on your section number! Look on your ISIS schedule.

Your assignment for week 1 (week of 6-9 Jan) is to go find both your discussion section location and the Chemistry Learning Center (CLC)!

EXAMS: Three progress exams and a **cumulative** final exam will be given in the course. All progress exams will be **given in the evening (8:20 pm start time)** and rooms will be assigned by section number and posted on Sakai so **learn your section number!** Be on time and bring a calculator (non-graphing) and pencil to the exam room nothing else. NO NOTES OR INFORMATION SHEETS, NO COMPUTERS, CELL PHONES or any information storage device electronic or paper. If you must be absent from an exam due to a documented and approved academic or UF athletic conflict, bring the documentation to your instructor beforehand (**at least one week prior to the scheduled exam**). You may take the exam early for approved reasons. You may not take exams late for any reason. Planned or emergency trips home or elsewhere are **not** approved conflicts.

No makeup progress exams will be given for any reason. We have no mechanism with such a large number of students for makeup exams. **Exam dates are clearly indicated on the syllabus.** **Final Exam keys/solutions will NOT be posted!** Final Exam may not be taken early. Grades will be posted within 24 hours most of the time. Should you not see your grade on Sakai it is YOUR responsibility to inform me. Students may NOT use graphing calculators on exams, you must use a scientific calculator with exponents, log and ln functions. No other device may be used as a calculator i.e. cell phone, iPods etc. **Calculator dies during the exam, no do-over. I suggest you bring a spare.** No cell phones are allowed in the exam rooms. **We do not curve exams so don't expect this.** Sample progress exams are posted. Do not use these as an absolute guide to the problems you will get this term.

Please note the exam absence link http://iteach.chem.ufl.edu/Exam_Absence_Policy_GChem_s13.pdf

Student Responsibilities:

1. **You are required to attend all classes and discussions.** (No you don't get points for doing what you are supposed to do like coming to class.) You don't show to class it is up to you to find out what you missed. You are responsible for everything I say in lecture even if you don't come. Read the syllabus and check the online notes. I have my class video recorded, how to access the videos will be posted. **DO NOT depend on reviewing these the day before exam or use them as an excuse for not attending class.** Note: You cannot sit and watch 3 hours in a row of my lectures and be successful in the class.
2. **You are required to read and follow the syllabus it is a grading contract.** You fail to comply and you will lose the points!
3. You must make check Sakai on a regular basis to make sure all your grades are posted or if an announcement is made. If you find something is wrong you must see me I will be glad to fix the problem. Come see me for missing electronic homework and exam grades and do so promptly. Do not wait until after the course ends (that is the last day of lecture), I will not be understanding.
4. Exam grades are posted promptly, usually within 24 hours unless we have a problem. So, if yours does not show see your instructor. **Scantron errors are not negotiable and you will pay the price in lost points for any and all errors.** This includes Form Code errors, registry errors, name and UFID numbers to name but a few. If you wait until the last few days of the semester to discover an incorrect grade you may lose points. **DO NOT WAIT TO POINT OUT A MISSED GRADE!** If you come to me after the last day of class you will lose the points no discussion!
5. **Final Exam keys/solutions will NOT be posted! You will NOT get to keep the Final Exam sheet!**
6. You must work "lots of problems", lots is different for everyone. These include end of chapter problems, problems on the notes / power point slides I have posted. Do not come to me with I did all the problems you said but still failed the exam. You take 20 minutes to do a problem at home but on the exam you have only 5 minutes to do the same problem. If you can't work a problem in 5 minutes you did not do enough problems!

7. You must keep up with the lecture material, the on-line homework and quiz material. All due dates are posted either on the syllabus or the course home page so you have no excuse what so ever for missing or not knowing a due date. At first you may know the material and think you can slack off, don't do this it will harm your grade. Keep working, things happen fast here and once you get behind you may not be able to catch up.
8. Please do not e-mail me with mundane and trivial questions. Read the syllabus and review the lecture video. If you want me to do something for you then you come see me at the start or end of class. Office hours will be posted on the course home page and on my office door. If I am in I will answer the phone.
9. If you need help get it early, help is available. The Chemistry Learning Center in Flint 257-278 it will have graduate students to assist you. A schedule with TA names and their times in the CLC will be posted on the course home page. You also have Broward Hall services.
10. Learn how to fill out a scantron. Scantron errors are not negotiable. This includes Form Code errors, registry errors, and name and UFID numbers. Make it hard for me to post your grade and you will lose points. You WILL BE penalized for scantron errors that require me to do extra work to get your grade into the Sakai grade book. First offense 9 points (this means that your grade will end in a 1 not a 0), second offense 18 points, third offense 24 points and fourth offense 36 points. It pays to learn how to fill out a scantron properly. A copy of a scantron is below look at it. We will give you a scantron for each exam at the start of the exam.
11. If you want to see your scantron you MUST come see me within 5 school days of the exam. They will not be e-mailed or given to a second party.
12. Need an interview for First year Florida I will do them usually in a group just after class. I will announce when at the start of class.
13. Class demeanor: You are expected to act appropriately for a lecture hall containing 300 students. Please turn your cell phone and other electronic devices not related to the class off. Your private conversations should be conducted outside of class and any communication should not disturb those next to you.
14. End of term demeanor: Your grad is the grade you earned. Grades are not negotiated, nor discussed. If you are missing a score you need to let me know and should have done so before the end of the class lectures as stated in class numerous times. It is absolutely inappropriate to request an increase in your grade when you haven't earned it. You are aware of every grade and within a very short time of taking the graded event (most often within 24 hours).

SCORING: Your grade for the term will be determined as follows:

Progress Exams (best 2 of 3@ 250 pts each)	500
Tutorials (best 10 of 12 @10 points each)	100
<u>On Line Assessments</u> Quizzes (best 10 of 12 @ 10 points each)	100
Final Exam	300
TOTAL	1000 pts

Grades will not be curved. The following grade cutoffs will be used: This is fixed; points **will not** go up. We are now using minus grades so your grade will be based on the scale below. **Note we do NOT use C-.** Off by one point you get the grade you earned.

A = 900 - 1000	B - = 760 - 799	D = 630 - 659
A - = 860 - 899	C + = 730 - 759	D - = 600 - 629
B+ = 830 - 859	C = 700 - 729	E < 600
B = 800 - 829	D + = 660 - 699	
	Failing grade	

Sakai: To access Sakai you should go to the website: <http://lss.at.ufl.edu> . Choose “Sakai”, then “University of Florida”. To log in, you must use your GatorLink username and password. If you do not yet have one, you must obtain one. If you have any problems with your GatorLink name or password you should contact the Help Desk at 392-HELP, or go to 520 CSE. They will only help you with GatorLink items, not WebCT problems. For the latter, see your instructor.

HONOR SYSTEM: All exams and online quizzes are given under the Honor System. Any student caught cheating will receive the maximum punishment I can bring to bear. (Cheating of any kind will result in a grade of E.) Check the website for the UF policy on honesty and cheating:
http://www.dso.ufl.edu/stg/Code_of_Conduct.html

UF students are bound by The Honor Pledge which states, “We, the members of the University of Florida community, pledge to hold ourselves and our peers to the highest standards of honor and integrity by abiding by the Honor Code. On all work submitted for credit by students at the University of Florida, the following pledge is either required or implied: “On my honor, I have neither given nor received unauthorized aid in doing this assignment.” The Honor Code <http://www.dso.ufl.edu/sccr/process/student-conduct-honor-code/> specifies a number of behaviors that are in violation of 3misconduct to appropriate personnel. If you have any questions or concerns, please consult with the instructor or TAs in this class.

CHEMISTRY LEARNING CENTER (CLC): There is free help to be had from graduate student teaching assistants in the CLC Monday through Friday in Flint Hall 257 and 258. Your discussion TA will have office hours in the CLC, but you may go there anytime and see any TA to get help on questions pertaining to chemistry. A schedule of the TA schedules will be posted in the corridor outside the CLC and on e-Learning.

The CLC ends their office hours the last day of class I will ask them to stay for the reading days. I end my office hours the last day of class.

STUDENT ATHLETES and official SCHOOL EVENTS: You must see me in person each and every time about taking a progress exam outside posted times that means early, but never late. You must contact me one week prior to the exam to arrange an early exam.

Coming to me at the last minute (less than a week prior to the exam) and you will not get to take an early exam.

DISABILITY RESOURCES:

Students with disabilities requesting accommodations should first register with the Disability Resource Center (352-392-8565, www.dso.ufl.edu/drc/) by providing appropriate documentation. Once registered, students will receive an accommodation letter which must be presented to the instructor when requesting accommodation. After getting the instructors signature students will then go to the disability resource center with the signed form. Students with disabilities should follow this procedure as early as possible in the semester.

The Dean of Students Office provides individualized assistance for students with documented disabilities. Services are based upon student need and impact of their specific disability. There is no requirement for any student to self-identify as having a disability. However, students requesting classroom accommodations must register with the Dean of Students Office and provide the appropriate documentation verifying their disability. The Dean of Students Office determines what is and is not appropriate documentation. Examples of accommodations that are available to students include, but are not limited to, registration assistance, approval of

reduced course load, course substitutions, classroom and examination accommodations, auxiliary learning aids, additional course drops when disability related, and assistance in other university activities. The designated coordinator for compliance with Section 504 of the Rehabilitation Act of 1973, as amended, and the Americans with Disabilities Act (ADA) is the Assistant Dean of Students responsible for Students with Disabilities Programs, P202 Peabody Hall, 392-1261 (Voice), or 392-3008 (TDD).

The Disability Resource Center strives to provide quality services to students with physical, learning, sensory or psychological disabilities, to educate them about their legal rights and responsibilities so that they can make informed decisions, and to foster a sense of empowerment so that they can engage in critical thinking and self-determination.

Other Information:

Counseling and Wellness Center: Contact information for the Counseling and Wellness Center: <http://www.counseling.ufl.edu/cwc/Default.aspx>, 392-1575; and the University Police Department: 392-1111 or 9-1-1 for emergencies.

Grading Policies: The current UF grading policies for assigning grade points can be found on the following link: <https://catalog.ufl.edu/ugrad/current/regulations/info/grades.aspx>.

Feedback: Students are expected to provide feedback on the quality of instruction in this course by completing online evaluations at <https://evaluations.ufl.edu>. Evaluations are typically open during the last two or three weeks of the semester, but students will be given specific times when they are open. Summary results of these assessments are available to students at <https://evaluations.ufl.edu/results/>.

Attendance: Requirements for class attendance and make-up exams, assignments, and other work in this course are consistent with university policies that can be found at: <https://catalog.ufl.edu/ugrad/current/regulations/info/attendance.aspx>.

Physical Sciences (P): Physical science courses provide instruction in the basic concepts, theories and terms of the scientific method in the context of the physical sciences. Courses focus on major scientific developments and their impacts on society, science and the environment, and the relevant processes that govern physical systems. Students will formulate empirically-testable hypotheses derived from the study of physical processes, apply logical reasoning skills through scientific criticism and argument, and apply techniques of discovery and critical thinking to evaluate outcomes of experiments.

General Education Student Learning Outcomes

The general education student learning outcomes (SLOs) describe the knowledge, skills and attitudes that students are expected to acquire while completing a general education course at the University of Florida. The SLOs fall into three areas: **content**, **communication** and **critical thinking**.

Area	Institutional Definition	Institutional SLO
CONTENT	Content is knowledge of the concepts, principles, terminology and methodologies used within the discipline.	Students demonstrate competence in the terminology, concepts, methodologies and theories used within the discipline.

COMMUNICATION	Communication is the development and expression of ideas in written and oral forms.	Students communicate knowledge, ideas, and reasoning clearly and effectively in written or oral forms appropriate to the discipline.
CRITICAL THINKING	Critical thinking is characterized by the comprehensive analysis of issues, ideas, and evidence before accepting or formulating an opinion or conclusion.	Students analyze information carefully and logically from multiple perspectives, using discipline specific methods, and develop reasoned solutions to problems.

Course Objectives and Goals: CHM 2045 (General Chemistry I)

You will be required to build a basic fund of knowledge of the science of chemistry covering the topics below: You will be required to analyze scientific concepts and think critically. This means being able to answer both quantitative (mathematical) and conceptual (quantitative) multiple choice problems in a limited period of time. Additionally you will have to write or orally communicate during your discussion periods. Progress exams allow 5 minutes per questions and the Final only 4 minutes per question. We will also demonstrate how these topics can be applied to the scientific method and how observation and experimentation leads us to the development of scientific theories. To achieve this, students will be introduced to the following concepts from the text *Chemistry the Molecular Nature of Matter and Change* by Silberberg.

You will review the importance of chemistry in our everyday lives. You will be required to utilize the methods of science as a logical means of problem solving through critical thinking. This means you must analyze information carefully and logically from multiple perspectives, using discipline specific methods, and develop reasoned solutions to problems. To ensure your competency in these concepts you will be required to complete online homework assignments and take quizzes and exams that require critical thinking, analysis of problems and drawing conclusions.

Critical Thinking

Critical thinking skills are essential in the general chemistry course. There are six criteria by which we promote critical thinking:

1. Information acquisition: Identifying and differentiating questions, problems and arguments.
2. Application: Assessing the suitability of various methods of reasoning and confirmation when approaching a problem. Students are taught to develop hypotheses and to find support and limitations associated with their hypotheses.
3. Analysis: Identifying and analyzing stated and unstated assumption and using logical reasoning to evaluate different viewpoints.
4. Synthesis: Students are encouraged to formulate questions and problems, construct arguments to address such questions and be able to effectively communicate conclusions.
5. Communication: In discussion of alternative points of view, students will be encouraged to criticize or defend their arguments with the use of logical reasoning and evidence.
6. Evaluation: Assessing the quality of evidence and reasoning to draw reasonable conclusions.

Mathematics

It is crucial in the general chemistry course to be competent in mathematics. Listed are the criteria by which we promote understanding and application of math:

1. Information acquisition: Students learn to select data that is pertinent to solving a problem.
2. Application: Use of algebraic, geometric and statistical reasoning to solve problems.
3. Analysis: Interpret and draw conclusions from formulas, graphs and tables.
4. Synthesis: To associate patterns and observations to more abstract principles and to consider specific applications of such principles.
5. Communication: Communicating mathematical information symbolically, graphically, numerically and verbally.
6. Evaluation: Estimate and verify solutions to mathematical problems to determine reasonableness, compare alternatives and select optimal results and understand the limitations of mathematical and statistical methods.

Concepts by Chapter:

The Foundation of Chemistry

Matter and Energy-Basic Concepts of Chemistry

Measurements

Significant Figures

Metric System

Scientific Notation

Dimensional Analysis

Chemical Formulas and Stoichiometry

Atoms, Ions, Molecules and Compounds

Nomenclature of Inorganic Compounds

The Mole Concept

Percent Composition

Empirical Formula

Molecular Formula

Chemical Equations and Reaction Stoichiometry

Balancing of Chemical Equations

Calculations Based on Chemical Equations-moles/masses of reactants/products

Limiting Reagent Calculations

Percent Yield and Theoretical Yield Calculations

Sequential Reactions

Concentration of Solutions-Calculations Involving Mass % and Molarity

Dilution of Solutions: Calculations Involving $V_1M_1=V_2M_2$

Calculations Involving Solution Stoichiometry

Chemical Reactions

Organization of the Periodic Table

Aqueous Solutions-Strong and Weak Electrolytes

Reactions in Aqueous Solutions

Oxidation Numbers

Thermodynamics

The First Law of Thermodynamics
Enthalpy, ΔH
Calorimetry (constant-pressure and constant volume)
Thermochemical equations
Internal energy, ΔE
Relationship between ΔE and ΔH
Hess' Law
Standard enthalpies of formation and reaction
Bond energy and ΔH
The Second Law of Thermodynamics & Spontaneity

The Structure of the Atom

Experiments that led to the discovery of the fundamental particles of the atom
Subatomic Particles, Isotopes, Atomic Weight
Development of Quantum Mechanics
Quantum Mechanical Model of the Atom
Electronic Configuration and the Relationship to the Periodic Table
Orbital Diagrams
Quantum Numbers
Chemical Periodicity

Theory of Ionic and Covalent Bonding

Lewis Dot Formulas of Atoms
Formation of Binary Ionic Compounds-Coulomb's Law, Lattice Energy
Formation of Covalent Compounds
Lewis Structures for Molecules and Polyatomic Ions and the Octet Rule
Resonance and Formal Charges
Exceptions to the Octet Rule for Lewis Structures
Polar and Nonpolar Covalent Bonds

Molecular Structure

Valence Shell Electron Pair Repulsion Theory (VSEPR)
Electronic and Molecular Geometry and Molecular Dipole Moments
Valence Bond Theory and Hybridization of Orbitals
Molecular Orbital Theory

Gases

Gas Laws and Ideal Gas Law
Density and Molar Mass
Stoichiometry of Reactions Involving Gases
Kinetic Molecular Theory-Molecular Speeds
Real Gases

Liquids and Solids

Intermolecular Attractions and Phase Changes
Physical Processes and Properties of Liquids
Melting Point/Boiling Point
Phase Changes of Matter and Phase Diagrams
Molar Heat of Vaporization and Molar Heat of Fusion

Solutions

Dissolution Process for Solids, Liquids and Gases

Factors Affecting Solubility

Saturated, Unsaturated and Supersaturated Solutions

Other Units of Concentration

Colligative Properties

1. Vapor Pressure Lowering
2. Boiling Point Elevation
3. Freezing Point Depression
4. Osmotic Pressure

Chemical Kinetics:

Rate of a reaction

Factors that affect reaction rates

a. Nature of reactants

b. Concentration of reactants: Rate-law expressions & Reaction order

c. Concentration vs. time: Integrated rate equations and half-life

Collision theory, activation energy

Transition state theory

Mechanisms and Rate-law expressions

Arrhenius equation: temperature and rate

Catalysts

[illegible]

Program Area Objectives

The general education program area objectives describe the context within which the [student learning objectives](#) are achieved.

General Education Student Learning Outcomes

The general education student learning outcomes (SLOs) describe the knowledge, skills and attitudes that students are expected to acquire while completing a general education course at the University of Florida. The SLOs fall into three areas: **content**, **communication** and **critical thinking**.

Every general education course must address all three SLOs. Note that the [program area objectives](#) describe the context within which the SLOs are achieved.

Area	Institutional Definition	Institutional SLO
CONTENT	Content is knowledge of the concepts, principles, terminology and methodologies used within the discipline.	Students demonstrate competence in the terminology, concepts, methodologies and theories used within the discipline.
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Physical Sciences (P)

Physical science courses provide instruction in the basic concepts, theories and terms of the scientific method in the context of the physical sciences. Courses focus on major scientific developments and their impacts on society, science and the environment, and the relevant processes that govern physical systems. Students will formulate empirically-testable hypotheses derived from the study of physical processes, apply logical reasoning skills through scientific criticism and argument, and apply techniques of discovery and critical thinking to evaluate outcomes of experiments.