CALIFORNIA STATE POLYTECHNIC UNIVERSITY, POMONA

ACADEMIC SENATE

GENERAL EDUCATION COMMITTEE

REPORT TO

THE ACADEMIC SENATE

GE-062-156

CHM 3010 – Modeling the Fundamentals of Physical Chemistry

General Education Committee	Date:	05/03/2017
Executive Committee Received and Forwarded	Date:	05/10/2017
Academic Senate	Date:	<u>05/17/2017</u> <u>First Reading</u> <u>05/31/2017</u> <u>Second Reading</u>

BACKGROUND:

This is a new course for the semester calendar.

RESOURCES CONSULTED:
Faculty
Department Chairs
Associate Deans
Deans
Office of Academic Programs

DISCUSSION:

The GE Committee reviewed the attached ECO for this course and found it to satisfy the GE Student Learning Outcomes and other requirements for GE Area B5.

RECOMMENDATION:

The GE Committee recommends approval of GE-062-156, CHM 3010 – Modeling the Fundamentals of Physical Chemistry for GE Area B5 (See attached ECO).

CHM - 3010 - Modeling the Fundamentals of Physical Chemistry

C. Course - New General Education* Updated

General Catalog Information

Department*	Chemistry and Biochemistry
Semester Subject Area*	CHM
Semester Catalog Number*	3010
Quarter Subject Area	CHM
Quarter Catalog Number	301
Course Title*	Modeling the Fundamentals of Physical Chemistry
Units*	(3)
C/S Classification *	C-02 (Lecture Discussion)

To view C/S Classification Long Description click: http://www.cpp.edu/~academic-programs/scheduling/Documents/Curriculum%20Guide/Appendix_C_CS_Classification.pdf

Component*	Lecture
Instruction Mode*	Fully Asynchronous, Web-Assisted

Grading Basis*	Graded Only
Repeat Basis*	May be taken only once
If it may be taken multiple times, limit on number of enrollments	1
Cross Listed Course Subject Area and Catalog Nbr (if offered with another department)	
Dual Listed Course Subject Area and Catalog number (If offered as lower/upper division or ugrd/grad)	
Choose appropriate type(s) of course(s)*	☐ Major Course ☑ Service Course ☑ GE Course ☐ None of the above
General Education Area / Subarea*	B5

To view the General Education SubArea definitions, click http://www.cpp.edu/~academic-programs/scheduling/Documents/Ch.3-GeneralEducationProposals.pdf.

I. Catalog Description

Catalog Description	In this course, students will examine models of thermodynamic properties of chemical species and mixtures, chemical kinetics, physical properties of molecules. Not a substitute for CHM 3040, CHM 3050, CHM 3110, or CHM 3120. Will satisfy GE area B5.

II. Required Coursework and Background

Prerequisite(s)	GE courses in areas A1, A2, A3, B1 (in chemistry), B2, B3, B4

Corequisite(s)	

Pre or Corequisite(s)	

Concurrent	

III. **Expected Outcomes**

List the knowledge, skills, or abilities which students should possess upon completing the course.*

On successful completion of this course, students will be able to:

Analyze data using a spreadsheet program to create mathematical models describing:

the thermodynamic properties of chemicals
chemical changes
physical changes
kinetics (chemical changes over time)
electronic spectroscopy of large molecules

Use words, equations, charts, and graphs to correctly explain:

a. predictions of how chemicals behave
b. how different quantities in the models indicate how various properties of chemicals are interrelated
c. how the models can explain everyday phenomena (e.g. why food is refrigerated or frozen)

Use many spreadsheet functions throughout the course while modeling chemical systems.

Explain how the course meets the description of the GE SubArea(s). Please select appropriate outcomes according to the GE Area/SLO mapping.	Physical Chemistry as a field of study uses the language of mathematics and the laws of physics to model chemical systems and the relationship of variables used to describe how materials behave. This course integrates quantitative reasoning and physics to produce models of chemical systems using technology. The goal of this non-majors, GE course is to provide students with an appreciation of what physical chemistry is, how modern models of real systems are developed and used, how technology is used to facilitate quantitative reasoning, and how these models can help explain how our bodies and the world around us works. This class is designed as a discovery based “learn by doing” course where students work on computer based modeling assignments with explicit instructions and then answer a series of scaffolded questions to explain the relationships revealed in the models.The best description is that of a “flipped” classroom where students are actively engaged in the modeling work during the class meeting time, and spend “out of class time” listening to lectures and ways to apply the models to other situations. A modeling assignment would consist of analyzing a set of data using technology and mathematics; small group discussions to make meaning from the results of the modeling; small group writing assignments about what the results mean and how the results apply to real world phenomena; and journaling individually about the assignment.These assignments promote critical thinking in writing and discussion; focus attention on understanding the interrelationships among the disciplines and their applications; allow for examination of ideas and issues in Area B in different ways that are deeper, broader, and more integrative; and encourage synthetic-creative thinking on order to identify (and solve) problems, understand broader implications, and construct original ideas. Additionally, these modeling assignments require students to identify and evaluate assumptions and limitations of ideas and models (e.g. non-ideal gases), deepen understandings about the meaning of the predictive power of models, and help develop written and oral communication skills appropriate for an upper division course.

This course includes primary sources such as those listed in IV; these have been chosen so they are accessible to non-majors and yet discuss experiments in the topics covered by the course. Lastly, the assignments for this course have been selected to enable assessment of student understanding of all of the learning objectives for the course including the GE Student Learning Outcomes. For all of these reasons, this course satisfies the requirements for a B5 course.

Describe how these outcomes relate to the associated GE Learning Outcomes listed below.*

As a General Education sub-area B5, the course addresses the following associated GE Student Learning Outcomes:

I a. Write effectively to various audiences.

Students work in small groups to construct written explanations of the models they build of chemical processes and systems. Students will be required to make an oral presentation or orally answer instructor questions (captured by video/audio recording) as needed to address this SLO.

I b. Speak effectively to various audiences.

In order to construct written explanations of models, students need to discuss the results of the modeling assignment and its meaning. The same is true for a group project – students must collaborate to produce a report on a class issue (e.g. a CHEMWiki entry)

I c: Locate, evaluate, and responsibly use and share data employing information and communication technologies.

Models are built upon data supplied in class that is accessible from Blackboard. For example, data sets might be obtained from Carl Yaws, Matheson Gas Data Book, June 25, 2001, McGraw-Hill Professional, New York."), and http://webbook.nist.gov/chemistry/ and cited (as well as discussed) in class.

During the take-home exams, students can explore the web to find strategies to solve exam problems, but must state the source of equations and other information used during the exam. A statement about this is on the cover sheet of every exam and is contained in the syllabus.

I d: Construct arguments based on sound evidence and reasoning to support an opinion or conclusion.

Following the construction of the mathematical model using a spreadsheet program, students are asked to explain not just what the model is, but what it means during each assignment.

I e. Apply and communicate quantitative arguments using tables, graphs, and equations.

Students work in small groups to construct explanations of the models they build of chemical processes and systems. Students can also collaborate to produce a report on a class issue (e.g. a CHEMWiki entry). Most of the explanations require students to include graphs, tables of data, and/or equations. Each model also requires students to submit the spreadsheet file containing the data, graph, and relationships discovered.

II a. Apply scientific methods and models to draw quantitative and qualitative conclusions about the physical and natural world.

Homework problems, exam questions, and the questions asked at the end of each mathematical modeling assignment require students to apply the models to the physical and natural world around us including quantitative and qualitative explanations.

II d: Integrate concepts, theories, and examples from more than one field of study to identify problems, draw conclusions, and construct original ideas.

Physical Chemistry as a field of study uses the language of mathematics and the laws of physics to model chemical systems and the relationship of variables used to describe how materials behave. This course integrates quantitative reasoning and physics to produce models of chemical systems using technology. The goal of this non-majors, GE course is to provide students with an appreciation of what physical chemistry is, how modern models of real systems are developed and used, how technology is used to facilitate quantitative reasoning, and how these models can help explain how our bodies and the world around us works.

General Education Outcomes*

- **Ia. Write effectively for various audiences**
- **Ib. Speak effectively to various audiences.**
- **Ic. Find, evaluate, use, and share information effectively and ethically.**
- **Id. Construct arguments based on sound evidence and reasoning to support an opinion or conclusion.**
- **Ie. Apply and communicate quantitative arguments using equations and graphical representations of data.**
- **IIa. Apply scientific methods and models to draw quantitative and qualitative conclusions about the physical and natural world.**
- **IId. Integrate concepts, examples, and theories from more than one discipline to identify problems, construct original ideas, and draw conclusions.**

To view the mapping, click https://www.cpp.edu/~academic-programs/Documents/GE%20SLO%20Mapping.pdf

IV. Instructional Materials

Provide bibliography that includes texts that may be used as the primary source for instruction, and other appropriate reference materials to be used in instruction. The reference list should be current, arranged alphabetically by author and the materials should be listed in accepted bibliographic form.

Instructional Materials*

Texts may vary with instructor and over time. Examples of possible texts include:

Raymond Chang, 'Physical Chemistry for the Biosciences', University Science Books, 2005 or CHEMWiki at http://chemwiki.ucdavis.edu/Physical_Chemistry

Primary resources might include:

1. Connelly, P.R., et.al, *PNAS* (**1994**), 91, 1964-1968 (Enthalpy of

hydrogen bond formation in a protein-ligand binding reaction)

2. Guisbiers, G., and Buchaillot, L., *J. Phys. Chem., C* **2009**, 113, 3566-3568 (Modeling the Melting Enthalpy of Nanomaterials)

3. Kebe, M., Renard, M.C.G., Amani, G.N.G., and Maingonnat, J.-F., J. Agric. Food Chem., 2014, 62, 9841-9847 (Kinetics of Apply Polyphenol Diffusion in Solutions with Different Osmotic Strengths)

Lectures, lecture notes, and current papers on the diverse topics will also be made available on BlackBoard by the instructor.

Faculty are encouraged to make all materials accessible. Indicate with an asterisk those items that have had accessibility (ATI/Section 508) reviewed. For more information, http://www.cpp.edu/~accessibility

V. Minimum Student Material

List any materials, supplies, equipment, etc., which students must provide, such as notebooks, computers, internet access, special clothing or uniforms, safety equipment, lockers, sports equipment, etc. Note that materials that require the assessment of a fee may not be included unless the fee has been approved according to University procedures.

Minimum Student Material*	A flash drive and/or cloud storage account Access to:computer Internet service e-mail Microsoft Office or equivalent Hardware to capture digital video (e.g. webcam) or audio (e.g. cell phone or recorder)

VI. Minimum College Facilities

List the university facilities/equipment that will be required in order to offer this class, such as gymnastic equipment, special classroom, technological equipment, laboratories, etc.

Minimum College Facilities*	**External Support** Library Services Information Technology (IT) Services Classroom Management System (e.g. BB) scanner **Physical Space & Major Equipment**

computer laboratory with 24-36 stations and seating for 24-36 students
smart classroom (computer/projector)
overhead screen
white board/dry erase markers
adjustable lighting
sufficient plug-ins to support numerous electrical devices

· If taught on campus: students each need a computer, so either a computer laboratory or wifi infrastructure to accommodate student computer internet access. Blackboard or other LMS is also required.

· If taught wholly on-line, faculty computer with internet access, Blackboard or other LMS that includes the ability of students to remotely work in groups to collaborate and submit group assignments, software to capture computer screen action, and hardware and software to produce video segments for classes.

VII. **Course Outline**

Describe specifically what will be included in the course content. This should not be a repetition of the course description but an expansion that provides information on specific material to be included in the class, e.g. lecture topics, skills to be taught, etc. This should not be a week-by-week guide unless all instructors are expected to follow that schedule.

Course Outline*

This course integrates ideas from physics and mathematics to model chemical systems using computer based methods.

The thermodynamics portion of the course includes topics such as:

· modeling of real gases

· heat capacity as a function of temperature
· how heat capacity is related to heat, enthalpy, and entropy
· how chemical equilibria is related to the Gibbs energy change of a reaction
· how vapor pressure varies with temperature, and
· colligative properties.

The kinetics portion of the course includes topics such as:
· Analysis of kinetic data
· Modeling of mechanisms

The spectroscopy portion of the course includes topics such as:

· 1-Dimension particle-in-a-box as a model for why compounds are colored

· Light-matter interactions (e.g. fluorescence, phosphorescence, photochromism)

This course is not intended to satisfy the requirement of Physical Chemistry for chemistry majors.

VIII. **Instructional Methods**

Describe the type(s) of method(s) that are required or recommended for the instruction of this course (lectures, demonstrations, etc.). Include any method that is essential to the course, such as the use of particular tools or software.

Instructional Methods*

Lecture
problem-solving
discussion
seminar
small-group activities
laboratory exercises/hands on practice
review, evaluation, critique
project (by individual, group, and/or class)
case studies
simulations
online tutorials
inquiry-based learning
project-based learning
assigned readings (textbook, journals, etc.)
journaling
modeling

This class is designed as a discovery based 'learn by doing' course where students work on computer based modeling assignments with explicit instructions and then answer a series of scaffolded questions to explain the relationships revealed in the models. The best description is that of a 'flipped' classroom where students are actively engaged in the modeling work during the class meeting time, and spend 'out of class time' listening to lectures and ways to apply the models to other situations.

Students need access to a spreadsheet and a computer. This choice was deliberate so students with access to any computer will be able to engage in the work of the course. The class requires a Learning Management System. Students are asked to engage in group work, so they need a way to collaborate and submit group work as well as gain access to the electronic files with assignments.

IX. **Evaluation of Outcomes**

Describe the methods to be used to evaluate students' learning, i.e. written exams, term papers, projects, participation, quizzes, attendance, etc.*

Students' learning of course content is evaluated via individual models, group constructed explanations of the results of the modeling assignments, homework assignments, midterm(s), final exam, and possibly a project. Weights in grade calculations might be 25% models, 15% homework, 10% oral communication,15% each midterm, and 20% final exam.

Describe the meaningful writing assignments to be included.*

Student's writing is assessed via the explanations of the models. Students submit at least 12 models – each modeling assignment requires students to complete an entry into a "learning journal". Each submission is responded to in order to increase students' abilities to produce technical writing.

A culminating writing assignment that has been used in this course in the past is to create an entry for the CHEMWiki (http://chemwiki.ucdavis.edu /Physical_Chemistry) on a topic from the course. These assignments are pair or small group assignments that have students delving more deeply into one topic of the course. This assignment has multiple submissions that have peer reviews and faculty input based upon a provided rubric.

Assignment	**Analyze data using a spreadsheet program to create mathematical models**	**Use words, equations, charts, and graphs to correctly explain**	**Use many spreadsheet functions throughout the course while modeling chemical systems**
Build and explain models	x	x	x
Homework	x	x	
Exams	x	x	x
Journals		x	
Modeling	x	x	x
Group collaboration		x	
Oral Presentation		x	

Assignment	**Ia (**Write effectively to various audiences.)	**Ib (S**peak effectively to various audiences.)	**Ic (**Locate, evaluate, and responsibly use and share data employing information and communication technologies.)	**Id (**Construct arguments based on sound evidence and reasoning to support an opinion or conclusion.)	**Ie (**Apply and communica quantitative arguments using table graphs, anc equations.)
Build and explain models	x	x	x	x	x
Homework				x	x
Exams	x		x	x	x
Journals	x			x	x
Modeling			x		x
Group collaboration	x	x	x	x	x

their understanding in writing. This is in compliance with the current standards for writing which include review and revision.

If students are constructing a ChemWiki article, there are two peer reviews (coupled with faculty input) and an additional faculty-only review of the article before final submission. All students receive a copy of the grading rubric for this assignment prior to starting the assignment.

1b. Speak effectively to various audiences.

Students will digitally record and submit (video or audio) files of small group discussions about modeling assignments and their meaning, an oral presentation, or orally answer questions posed by instructor.

1c: Locate, evaluate, and responsibly use and share data employing information and communication technologies.

Students are required to locate, use and share the data for the course. Posting everything for the course on Blackboard requires students to download, use, analyze, upload, collaborate, etc. on-line.

During exams, students are allowed to locate and use data from on-line resources, but must cite their sources. If this is not done, students are prosecuted for plagiarism. A statement about this is on the cover sheet of every exam and is contained in the syllabus.

1d. Construct arguments based on sound evidence and reasoning to support an opinion or conclusion.

After working with the data sets, students must collaborate, argue, and construct explanations based upon the models built using the data available during the assignment. Student responses to synthesis questions posed in each module must be based upon the evidence in the data.

1e. Apply and communicate quantitative arguments using tables, graphs, and equations.

Each module asks students to work with data (presented as numbers) to deduce relationships (equations) between variables in the data and/or other data sets. The instructions for each data set includes instructions about what to graph and to explain the meaning of the graph and the resulting equation and relationship discovered during the analysis of the data.

2d: Integrate concepts, theories, and examples from more than one field of study to identify problems, draw conclusions, and construct original ideas.

Physical chemistry is a chemistry capstone type of course that uses the language of mathematics and the models of the natural world constructed in physics to explain the behavior of chemical systems. The data sets used in the course are designed to integrate these fields. An example from the course is contained in multiple modeling assignments which are nested, but which lead students to uncover important ideas in the field of physical chemistry. One way to do this is to 1) determine an equation that describes how the heat capacity of a gas molecule changes as the temperature changes, 2) build a model of 4 integrated (mathematically integrating numerically) functions of the heat capacity as a function of temperature, 3) compare heat (and enthalpy and entropy) to the integrated functions to discover the relationship between heat and heat capacity. The students are asked to both describe in words and equations this relationship.

Describe the meaningful writing assignments to be included.

Student's writing is assessed via the explanations of the models. Students submit at least 12 models – each modeling assignment requires students to complete an entry into a 'learning journal'. Each submission is responded to in order to increase students' abilities to produce technical writing.

A culminating writing assignment that has been used in this course in the past is to create an entry for the CHEMWiki (http://chemwiki.ucdavis.edu/Physical_Chemistry) on a topic from the course. These assignments are pair or small group assignments that have students delving more deeply into one topic of the course. This assignment has multiple submissions that have peer reviews and faculty input based upon a provided rubric.

X. **This OPTIONAL Section is for describing Course/Department/College specific requirements.**