# PHY 123
# Food, Fire, and Physics: The Science of Cooking

Instructor: Dr. Kevin B. Aptowicz

(revised: January $17^{th}$, 2018)

**Course Summary**

Welcome to Food, Fire, and Physics: The Science of Cooking. This course will explore food and cooking from a physical science perspective. In particular, we will use principles in soft matter physics (e.g. phase diagram, intermolecular forces, diffusion, elasticity, viscosity) to gain a deeper understanding of food and cooking. Each week we will explore a different topic. This exploration will be both quantitative and qualitative as we try to unwrap the mysteries of cooking. It is my sincere hope that, by the end of the semester, your view of food and cooking will have dramatically evolved. Furthermore, I hope this represents the start of a lifelong journey where you think about the science of food and cooking with many culinary conquests ahead.

## Contents

# 1 Objectives

PHY123 is an approved course in the WCU General Education program and counts as a science elective. It is designed to help students meet the following general education goals:

- Goal #2 Employ qualitative concepts and mathematical models
- Goal #3 Think critically and analytically

These goals will be achieved as students wrestle with the central concepts of the course and apply both scientific principles and utilize scientific expressions. We will study physical phenomena that are relevant to cooking including heat, temperature, molecular bonds, heat transfer, phase transitions, elasticity, diffusion, viscosity, emulsions, gels, and foams. A list of representative learning outcomes for the course are as follows:

| **Select Course Learning Outcomes** |
|---|
| Students will be able to analyze the phases of matter using a molecular model that is based on energy considerations and intermolecular forces. |
| Students will be able to describe macroscopic properties of matter like temperature, viscosity, elasticity, using microscopic and molecular models. |
| Students will be able to interpret a phase diagram graph to determine the state of matter for a given pressure and temperature. |
| Students will be able to interpret a phase diagram graph to determine the state of matter for given conditions. |
| Students will be able to quantitatively define stress and strain. |
| Students will be able to qualitatively identify matter based on their mechanical properties (e.g. viscoelasticity). |
| Students will be able to distinguish between different heat transfer methods of conduction, convection, and radiation. |
| Students will be able to identify the physical properties of the four basic food molecules (water, lipids, carbohydrates, and proteins) |
| Students will be able to describe how the key physical properties of the four basic food molecules (water, lipids, carbohydrates, and proteins) is determined by their molecular structure. |
| Students will be able to identify different types of colloids (foams, emulsions, gels, and sols) based upon physical description of the matter. |
| Students will be able to describe the structure of a polymer and explain how carbohydrates and proteins are polymers. |
| Students will be able to describe protein denaturation by heat and by acid. |

In addition, I have some unofficial goals that have guided the construction of this course. They are:

- That students thoroughly enjoy the course and find it a fulfilling experience.
- That students end the course inspired to go into their own kitchen and experiment with different cooking techniques.
- That students continue to think about food and cooking from a scientific perspective for the rest of their lives. (I know, this is a bit ambitious.)

# 2 Course Information and Required Materials

| | |
|---|---|
| **Course:** | PHY 123 - Food, Fire, and Physics: The Science of Cooking |
| **Required Material:** | **Textbook** - *On food and cooking: the science and lore of the kitchen* McGee, Harold, 2004. Publisher: Scribner<br>**Calculator** - A stand-alone calculator that is not part of a cellphone or other internet-accessible personal electronic device. The calculator could be a simple scientific calculator that can calculate logarithmic and exponential functions (e.g. log(100) or $e^{\left(\frac{3}{5}\right)}$) and powers (e.g.$\sqrt{1024}$). These functions are all standard on scientific calculators. As an example, TI-30Xa (~$10) or TI-30X IIS (~$13) would do the trick. Again, you cannot use a cell phone. |
| **Website**: | Course materials are housed on D2L. |
| **Lecture Location:** | Schmucker Science Link, Room 151 |
| **Lecture Times:** | Tuesday & Thursday<br>12:30 pm to 1:45 pm |
| **Instructor:** | Kevin B. Aptowicz (Dr. Aptowicz) |
| **Office Location:** | 227 Schmucker Science Center South |
| **Office Phone:** | (610) 436-3010 |
| **Email:** | kaptowicz@wcupa.edu |
| **Office Hours:** | Monday 10 am to 12 pm<br>Tuesday 3 pm to 4 pm<br>Thursday 9:30 to 10:30 am<br><br>In addition, the teaching assistance for the course will also be holding office hours. Their office hours we be posted at the start of the semester. |

# 3 Course Structure

How do we accomplish the objectives set forth in Section 1? It will require effort on both our parts. You will need to be a dedicated student with good time-management skills. In addition, you will need enough confidence to keep your chin up during rough stretches. I will need to develop pedagogically sound teaching tools that make efficient use of your valuable time and directly address those concepts or material that you find most challenging. This section gets at the heart of both of our roles and addresses how your time will be spent inside and outside the classroom.

## 3.1 The Calculation ... Student's Time on Task

The life of a student isn't easy. You have many demands on your time beyond this Gen Ed course. I need to be reasonable by not assigning more work than is humanly possible. This calculation is an attempt to due just that. In order to determine how much time a student can commit to PHY 123, I've made the following assumptions.

- The student (that's you!) spends a total of 45 hours a week on his or her college studies.
- The student course load is 15 credits.

Therefore, the total time a student is able to commit to this course per week is $\frac{45\text{ hours}}{15\text{ credits}} \times 3\text{ credits} = 9\text{ hrs}$. However, this is a Gen Ed course and thus should not be as intensive as a course in one's major. Thus, I'm designing the course assuming you will dedicate 7 hours a week to this course. These precious hours are allotted to the following tasks.

Table 1: Student time on task per week.

| Task | Time (hrs) |
|---|---|
| actively participating in lecture | 3 |
| preclass reading | 2 |
| completing weekly assignment | 2 |

## 3.2 Recommended Weekly Schedule

It's all about time management! Learning physics' concepts and procedures takes time ... lots of time. You must practice applying the concepts and principles multiple times and work diligently at clearing up any misconceptions. If you create a regular weekly schedule for studying physics and take the course one step at a time, you will be shocked with the results. If you wait to the last minute and try to cram for an exam, the results will be disastrous. I'm expecting that you will spend 7 hours a week on this course. To spread out the work evenly over the week, I recommend the following schedule:

| Day | Activity | Time |
|---|---|---|
| Monday | Read for Tuesday's lecture<br>Make sure to submit the problem set on D2L. | ∼1 hour |
| Tuesday | Attend class / Work on problem set | ∼2 hour |
| Wednesday | Read for Thursday's lecture. | ∼1 hour |
| Thursday | Attend class / Work on problem set | ∼2 hour |
| Friday | Finish up problem set | ∼1 hour |
| Saturday | Take a break!!! | |
| Sunday | Take a break ... and do some cooking! | |

## 3.3 Course Components

Here is a list of the different aspects of the course and the thinking behind each one.

**Preclass Reading** Yes, you must read form the required text before coming to class. By doing the preclass reading, I will be able to allot sufficient time on the more challenging concepts during lecture which will payoff when you complete the problem sets. The required textbook is the acclaimed *On food and cooking: the science and lore of the kitchen* by Harold McGee. It is an excellent book as indicated by the many positive reviews on Amazon. I'm hoping you will not dread the reading assignments but instead look forward to them. You should be able to read a page of the text in less than 5 minutes, so I will make sure not to assign more than 12 pages per lecture (about an hour of reading).

**Reading Quizzes** We will start the lecture with reading questions. These will help you assess if you are processing the reading. When I assign the reading, I will also provide you with reading questions so you know what to focus on when doing the reading. The contents of the reading assignments will also be utilized for problem sets and exams.

**Lecture** You should be familiar with this part. I attempt to make it engaging and encourage lots of questions.

**Cooking Demonstrations** Three times during the semester, Chef Jason Lewis will visit our class and show off some neat cooking techniques that build upon the science concepts we have been discussing.

**Concept Questions** This is a pedagogical tool to test whether you understand the main point I'm trying to make during lecture. I might also use it to check if you understand a subtle issue. Concept Questions also improve your ability to discuss and explain your critical and analytical thinking with your classmates. They promote active thinking during lecture time (rather than rote note-taking) which is critical to the learning process.

**Problem Set** Each week, I'll post a problem set on D2L. The problem set will become available on Tuesday. It will be due the following Monday. However, my hope is that you submit it by Friday and enjoy the weekend!

**Exams** There will be two multiple-choice exams during the semester. These are indicated in the schedule below.

**Catered Review Session** At the end of the semester, Aramark will sponsor a catered reveiw session for the entire class. This will serve as a review session for the course in which you will be asked questions about the science of the food you are eating!

**Final Exam:** The final exam is a cumulative exam that occurs at the end of the course.

**Bonus Kitchen Experiments:** Throughout the course of the semester, there will be opportunities to do experiments in your kitchen. If completed, you can submit the results of these experiments for bonus credit. This bonus credit will be added to your exam scores.

# 4 Grading Procedure

Grades! For some, this is the only section that matters. Enjoy.

## 4.1 Methods for Calculating Your Grade

To account for different student approaches to this course, I have devised two grading methods. The first method is geared towards diligent students who put in the effort all semester long but struggle on exams. The second method is to for those students who struggle with time management skills (e.g. doing the reading, finishing the problem sets), but get it together to do well on the exams. If you are a diligent student and do well on the exams, don't worry, you'll do well by both methods! I'll use both methods to calculate your course grade and then use the resulting highest grade for your grade in this course.

**Method #1**

| | |
|---|---|
| Problem Sets | 30% |
| 1st Exam | 25% |
| 2nd Exam | 25% |
| Final Exam | 20% |

**Method #2**

| | |
|---|---|
| Problem Sets | 10% |
| 1st Exam | 30% |
| 2nd Exam | 30% |
| Final Exam | 30% |

## 4.2 Letter Grade Assignment

I assign letter grades according to the following scale.

| Numerical Grade | Letter Grade |
|---|---|
| 93.4 - 100.0 | A |
| 90.0 - 93.3 | A- |
| 86.7 - 89.9 | B+ |
| 83.4 - 86.6 | B |
| 80.0 - 83.3 | B- |
| 76.7 - 79.9 | C+ |
| 73.4 - 76.6 | C |
| 70.0 - 73.3 | C- |
| 66.7 - 69.9 | D+ |
| 63.4 - 66.6 | D |
| 60.0 - 63.3 | D- |
| below 60.0 | F |

I do not norm-reference (or scale) grades.

# 5 Course Policies

Numerous course policies can be found below. If you need more details or have a question, stop by my office.

## 5.1 Academic Integrity and Code of Conduct

It is the responsibility of each student to adhere to the university's standards for academic integrity. Violations of academic integrity include any act that violates the rights of another student in academic work that involves misrepresentation of your own work, or that disrupts the instruction of the course. Other violations include (but are not limited to): cheating on assignments or examinations; plagiarizing, which means copying any part of another's work and/or using ideas of another and presenting them as one's own without giving proper credit to the source; selling, purchasing, or exchanging of term papers; falsifying of information; and using your own work from one class to fulfill the assignment for another class without significant modification. Proof of academic misconduct can result in the automatic failure and removal from this course. For questions regarding Academic Dishonesty, the No-Grade Policy, Sexual Harassment, or the Student Code of Conduct, students are encouraged to refer to their major department's handbook, the Undergraduate Course Catalog, the Rams Eye View, or the University Web Site. Please understand that improper conduct in any of these areas will not be tolerated and may result in immediate ejection from the class.

## 5.2 Screens Policy

It is critical that students remains engaged during class time and focused on the challenging concepts being discussed. Thus, devices (phones, tablets, laptops, etc.) use is strictly forbidden in class. Please do not leave cellphone on your laps or other locations where they might distract you. All cellphone must be packed away. For each infraction, the student's overall course grade may be reduced by a third of a letter grade. If an emergency situation arises and you need to check your cellphone, please excuse yourself from the class and check your cellphone in the hallway.

## 5.3 Excused Absence Policy

Students are advised to carefully read and comply with the excused absences policy for university-sanctioned events contained in the WCU Undergraduate Catalog. In particular, please note that the "responsibility for meeting academic requirements rests with the student," that this policy does not excuse students from completing required academic work, and that professors can require a "fair alternative" to attendance on those days that students must be absent from class in order to participate in a University-Sanctioned Event.

## 5.4 Exams Policy

There are no make-up exams. If you miss an exam for an unexcused absence, you will receive a zero for that exam. If you miss an exam for an excused absence, please meet with me to discuss a possible solution.

## 5.5 Problem Sets

Assigned problems will be graded every week. If you do not submit your work for the week, you will receive a zero. You can miss one problem set and it will not negatively impact your grade.

## 5.6 Attendance and Lateness Policy

If you are late to class and the reading quiz have been conducted, you will not be allowed to take the quiz. Note: two reading quiz grades are dropped when calculating your final quiz grade.

## 5.7 Teaching Style

This course will rely heavily on lectures using the chalk boards as well as concept questions projected onto a screen. If you have problems seeing the chalk board or reading my handwriting, please move to the front of the class.

## 5.8 LGBTQA Ally

Based on West Chester University's commitment to diversity, I believe that everyone in my classroom should feel safe. I have completed the University's Lesbian, Gay, Bisexual, Transgender, Queer, Questioning Ally training. In becoming an ally I made the commitment to offer a safe space for all of my students, not just those who identify as LGBTQA. If you or someone you know would like to know more about this program, or needs to speak confidentially about issues of sexual orientation or gender identity, please feel free to see me during my office hours.

## 5.9 Americans with Disabilities Act

If you have a disability that requires accommodations under the Americans with Disabilities Act (ADA), please present your letter of accommodations and meet with me as soon as possible so that I can support your success in an informed manner. Accommodations cannot be granted retroactively. If you would like to know more about West Chester University's Services for Students with Disabilities(OSSD), please contact the OSSD which is located at 223 Lawrence Center. The OSSD hours of Operation are Monday – Friday 8:30 a.m. – 4:30 p.m. Their phone number is 610 - 436 - 2564, their fax number is 610 - 43 6 - 2600 , their email address is ossd@wcupa.edu , and their website is at www.wcupa.edu/ussss/ossd .

## 5.10 Public Safety

All students are encouraged to sign up for the University's free WCU ALERT service, which delivers official WCU emergency text messages directly to your cell phone. For more information and to sign up, visit www.wcupa.edu/wcualert. To report an emergency, call the Department of Public Safety at 610-436-3311.

## 5.11 Intellectual Property

Intellectual Property Statement: The instructor for this course utilizes copyrighted materials under the "Freedom and Innovation Revitalizing United States Entrepreneurship Act of 2007" (Fair Use Act). Apart from such copyrighted materials, all other intellectual property associated with this course is owned and copyright protected by the instructor, including, but not limited to, lectures, course discussions, course notes and supplementary materials posted or provided to students authored by the instructor, assessment instruments such as quizzes and exams, and Power Point presentations. No recording, copying, storage in a retrieval system, or dissemination in any form, whether electronic or other format, by any means of the intellectual property of the instructor, either in whole or in part, is permitted without the prior written permission of the instructor. When such permission is granted, it must specify the utilization of the intellectual property and all such permissions and waivers shall terminate on the last day of finals in the semester in which this course is held.

Links and references to on-line resources provided by the instructor may lead to other sites. The instructor does not sponsor, endorse or otherwise approve of any information appearing in those sites, nor is responsible for the availability of, or the content located on or through, external sites. Apart from materials used in accordance with the Fair Use Act, the instructor takes no responsibility for material that is otherwise offered at web sites and makes no warranty that such material does not infringe any third party rights. However, should any of this type of material be present and this fact is brought to the attention of the instructor, they will remove references to it from course materials.

# 6 Schedule

Wow, you made it all the way to the schedule. Almost done. Here is the schedule of topics, exams, and special events for the class.

| Week | Date | Day | Topic |
|---|---|---|---|
| 1 | Jan 23 | Tu | Introduction / Unit Conversion |
| 1 | Jan 25 | Th | Unit Conversion / Visit from Chef Jason Lewis |
| 2 | Jan 30 | Tu | Food Components |
| 2 | Feb 1 | Th | Food Components |
| 3 | Feb 6 | Tu | Temperature, Heat, Energy |
| 3 | Feb 8 | Th | Temperature, Heat, Energy |
| 4 | Feb 13 | Tu | Phase Transitions |
| 4 | Feb 15 | Th | Phase Transitions |
| 5 | Feb 20 | Tu | Elasticity |
| 5 | Feb 22 | Th | Elasticity |
| | Feb 27 | Tu | Battle of the Colleges / Visit from Chef Jason Lewis |
| | Mar 1 | Th | EXAM #1 |
| S.T. | Mar 6 | Tu | Special Topics ... online content |
| S.T. | Mar 8 | Th | Special Topics ... online content |
| | Mar 13 | Tu | SPRING BREAK |
| | Mar 15 | Th | SPRING BREAK |
| 6 | Mar 20 | Tu | Diffusion |
| 6 | Mar 22 | Th | Diffusion |
| 7 | Mar 27 | Tu | Heat Transfer |
| 7 | Mar 29 | Th | Heat Transfer |
| 8 | Apr 3 | Tu | Viscosity |
| 8 | Apr 5 | Th | Viscosity |
| 9 | Apr 10 | Tu | Emulsions and Foams |
| 9 | Apr 12 | Th | Emulsions and Foams |
| 10 | Apr 17 | Tu | Fermentation & Enzymatic Reactions |
| 10 | Apr 19 | Th | Fermentation & Enzymatic Reactions |
| | Apr 24 | Tu | Battle of the Colleges / Visit from Chef Jason Lewis |
| | Apr 26 | Th | EXAM #2 |
| | May 1 | Tu | Catered Review Session - Sykes Ballroom |
| | May 3 | Th | Review |
| | May 8 | Tu | **FINAL EXAM** (1 pm - 3 pm) |

# 7 Bibliography

The only required textbook for this course is:

- McGee, Harold. *On food and cooking: the science and lore of the kitchen.* Scribner, 2004.

This is a classic text that gives a general overview of the scientific concepts underlying cooking. More specific texts covering the scientific aspects of cooking, and the basic science, are listed below.

Other books on science and cooking:


1. Corriher, Shirley O. *Cookwise: the hows and whys of successful cooking.* William Morrow, 1997.
2. McGee, Harold. *The curious cook: More kitchen science and lore.* North Point Press, 1990.
3. This, Hervé, and Jody Gladding. *Kitchen mysteries: Revealing the science of cooking.* Columbia University Press, 2010.

4. This, Hervé. *The science of the oven.* Columbia University Press, 2009.

5. Beckett, Stephen T. *The science of chocolate.* Royal Society of Chemistry, 2008.

6. Clarke, Chris. *The science of ice cream.* Royal Society of Chemistry, 2012.

7. Ruhlman, Michael. *Ratio: The Simple Codes Behind the Craft of Everyday Cooking.* Scribner, 2009.

8. Barham, Peter. *The science of cooking.* Springer Verlag, 2001.

9. Potter, Jeff, and Michael Ruhlman. *Cooking for Geeks.* O'Reilly Media, Incorporated, 2010.

10. Crosby, Guy. *The science of good cooking : master 50 simple concepts to enjoy a lifetime of success in the kitchen.* Brookline, MA: America's Test Kitchen, 2012.

11. López-Alt, J. Kenji. *The Food Lab: Better Home Cooking Through Science.* W. W. Norton & Company, 2015.

Cookbooks written by chefs:

11. Achatz, Grant. *Alinea.* Achatz, 2008.

12. Blumenthal, Heston. *The fat duck cookbook.* Bloomsbury, 2009.

13. Adrià, Ferran, Albert Adrià, and Juli Soler. *A Day at elBulli.* Phaidon, 2010.

14. Andrés, José, and Richard Wolffe. *Made in Spain : Spanish dishes for the American kitchen.* New York: Clarkson Potter/Publishers, 2008.

15. Yosses, Bill, and Melissa Clark. *The Perfect Finish: Special Desserts for Every Occasion.* WW Norton, 2010.

16. Peternell, Cal. *Twelve Recipes.* William Morrow Cookbooks, 2014.

Scientific books:

16. Jones, Richard A. *Soft condensed matter.* Oxford New York: Oxford University Press, 2002.

17. Witten, T, and P. A. Pincus. *Structured fluids : polymers, colloids, surfactants.* Oxford New York: Oxford University Press, 2004.

18. Rubinstein, Michael, and Ralph H. Colby. *Polymer physics.* Oxford New York: Oxford University Press, 2003.

19. Hirst, Linda S. *Fundamentals of soft matter science.* Boca Raton: CRC Press, 2013.

20. Hamley, Ian W. *Introduction to soft matter : synthetic and biological self-assembling materials.* Chichester, England Hoboken, NJ: John Wiley & Sons, 2007.