ECM 1, Spring Quarter 2016

The Design of Coffee

GE Credit: Science and Engineering; Visual Literacy and Scientific Literacy (3 units)

Instructors

Prof. William Ristenpart & Prof. Tonya Kuhl

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Schedule

Lecture: Mondays 7:10 pm – 8:00 pm, in Sciences Lecture Hall 123

Laboratory: 2 hours weekly, in Everson Hall room 126

Required lab manual

The Design of Coffee: An Engineering Approach, by Ristenpart & Kuhl

(ISBN: 1516894782, available at Amazon.com)

Office hours

Prof. Ristenpart: Friday 9:00 – 9:50 am, 3012 Bainer Hall

Prof. Kuhl: Monday 2:10–4:00 pm, Tuesday 3:10–4pm, 3106 Bainer Hall

TA Office Hours: see detailed schedule

Course Objective:

This class is intended to serve as a non-mathematical introduction to how engineers approach and solve problems, as elucidated by the process of roasting and brewing coffee. The instructors will provide qualitative overviews of the basic principles of engineering analysis and design, and then guide the students in corresponding laboratory experiments testing the effect of design choices on the sensory qualities of coffee. In this manner, students will learn that even a process with only two "chemicals" – coffee beans and water – can have tremendous variability depending on the design choices.

Grading:

Weekly lab write-ups	(Group)	40%
Design project video	(Group)	25%
Midterm exam (May 23)	(Individual)	25%
Lab conduct, safety, cleanup	(Individual)	10%

There is no final exam; you instead submit the final design project video. You can ignore the final exam schedule posted by the registrar for this course.

Course Format:

Each week will begin with a 50 minute instructor-led discussion about a different chemical engineering principle, with a focus on how that principle is manifested in the production of coffee. We will then go into the laboratory to perform complementary experiments to elucidate or test those engineering principles – and then of course to taste the resulting coffee!

On most weeks a short "pre-lab" reading assignment from the lab manual will be due prior to the lab exercises (typically focusing on the key scientific ideas underlying the lab.) The lab exercises themselves will typically be performed in groups of three students. After the lab, each group will submit via Smartsite a short lab report summarizing their qualitative and/or quantitative findings, typically due before the next lab. Late reports lose 25% per day; your name and student ID number must be on the report to receive credit. *Your lowest lab report score will be dropped.*

In the final week of the course, each group will prepare their "ideal cup of coffee" that will be judged in a blind taste testing. The winning group from the "play-off round" will move to the championship round, scheduled for "dead day" on Friday, June 3. Each group will prepare a maximum 5-minute long video that describes their design decisions and results (described below in more detail). Your group's design project video must be submitted via Smartsite by end of day, Monday, June 6.

There will be one multiple choice midterm exam, on Monday, May 23 at 7:10 pm (during regular lecture time). Bring an official UC Davis Scantron! There is no final exam for this course; you instead submit your final video project. Ignore the final exam schedule posted by the registrar for this course.

Safety:

All labs will be conducted in the Everson Hall 126, which is a *food-grade facility*. Unlike most labs on campus, you *are* allowed to eat or drink food within this lab. This means, however, that absolutely no hazardous chemicals or materials are allowed inside, only food grade products. Furthermore, hygiene is important. Everyone must wash their hands upon entering the lab, and help clean-up their station at the end of lab. Only drink from your own cup. Lab coats and gloves are *not* necessary.

The main safety hazard in this course is the risk of burns: the coffee pots and roasters can get hot enough to cause *severe burns* if contacted with bare skin. Exercise great caution around them; note that "horseplay" or other misconduct will result in expulsion from the laboratory and almost definitely a failing grade in the course. The other safety hazard involves fires: just like bread can catch fire in a toaster, *coffee beans can catch fire in a roaster*. Never leave the roaster unattended, and pay special attention to the instructor and TA guidelines on safe use of all equipment. If you have any safety questions at any time, do not hesitate to ask!

Coffee Design Project:

The main goal of the coffee design project is to make the best cup of coffee, using the least amount of electrical energy. Each group will receive a score defined by the ratio

$$\text{Final Score} = \frac{\text{Blind Taste Test Score}}{\text{Total Electrical Energy}}$$

This score is for the contest only, and **does not directly affect your grade** (except inasmuch that winning the contest will earn you bonus points!) The group in each section that receives the highest final score 'wins' the design project and will receive a bonus. The inputs into the final score are defined as follows.

- The coffee will be judged in a blind taste test by a panel of your peers on a scale of -10 to 55 (where -10 is the worst cup of coffee in the history of mankind, and 55 is nirvana in a cup.) The scores from each of the panelists will be averaged together.
- Your group must keep track of how many kilowatt-hours of electrical energy you used during the entire process of roasting and brewing your coffee. Any piece of equipment you plug into an outlet must be monitored using the energy meter and included.

In the final weeks of the course, your group will use MovieMaker, Powerpoint, and/or other software video editing tools to create a video presenting your final design, including the process flow diagram, mass balances, energy usage and sensory impressions. Exact requirements are described in the lab manual. The grade for your design project video is broken down as follows: technical description of the design, 60%; quality of the video, 30%; creativity and originality of the movie and/or design, 10%. Bonus points are available for coffee quality (taste & energy usage), if you achieve third place or better during the play-offs and/or championship.

ECM 1 Schedule, Spring 2016		
Date	**Lecture**	**Laboratory Experiment**
28-Mar	What is chemical engineering, & what does it have to do with coffee?	*(Virtual)* Lab 0 - Safety overview (no labs)
4-Apr	Material Balances: An overview of making coffee	Lab 1 - Reverse Engineering a Drip Coffee Brewer
11-Apr	Chemical Reactions: Roasting and brewing to perfection	Lab 2 - Process Flow Diagram & Mass Balances for Coffee
18-Apr	Energy Balances: What is energy, and how is it used in coffee?	Lab 3 - The pH of Coffee & Chemical Reactions
25-Apr	Mass Transfer: Extraction as the heart of coffee	Lab 4 - Measuring the Energy Used to Make Coffee
2-May	Fluids and Colloids: Coffee as a colloidal suspension	Lab 5 - Mass Transfer and Flux during Brewing
9-May	Process Design: Putting it all together	Lab 6 - Coffee as a Colloidal Fluid and the Effect of Filtration
16-May	Guest lecture	Lab 7 - First Design Trials: Optimizing Strength & Extraction
23-May	Midterm Exam (during regular lecture time)	Lab 8 - Second Design Trials: Scaling Up to 1 Liter of Coffee
30-May	*Holiday - no lecture*	Lab 9 - Design Competition & Blind Taste Panel

ECM 1 Schedule - Spring 2016					
	Monday	Tuesday	Wednesday	Thursday	Friday
8:00 AM		ECM 1 - A15	ECM 1 - A05	ECM 1 - A10	
9:00 AM	***Head TA***	***WDR/TLK***	***DAN***	***BEN***	
10:00 AM	***O.H.***	ECM 1 - A01	ECM 1 - A06	ECM 1 - A11	*OH 4*
11:00 AM		***ARIEL***	***DAN***	***BEN***	***ATHARVA***
12:00 PM	**TA Meeting**	ECM 1 - A02	ECM 1 - A07	ECM 1 - A12	*OH 5*
1:00 PM	*OH 1*	***ARIEL***	***PEI***	***JAMES***	***DAN***
2:00 PM	***ARIEL***	ECM 1 - A03	ECM 1 - A08	ECM 1 - A13	*OH 6*
3:00 PM	*OH 2*	***ATHARVA***	***PEI***	***JAMES***	***AREF***
4:00 PM	***PEI***	ECM 1 - A04	ECM 1 - A09	ECM 1 - A14	*OH 7*
5:00 PM	*OH 3*	***ATHARVA***	***AREF***	***AREF***	***BEN***
6:00 PM	***JAMES***				
7:00 PM	**ECM 1 Lec**				
8:00 PM					
		All labs and TA office hours to be held in Everson 126			

Green boxes: regularly scheduled lab sections. You may not attend unless you are in that section.
Purple boxes: open lab office hours, intended for you to perform make-up labwork, or to ask questions about reports.