THE ART & SCIENCE
OF BREWING

UC Davis Extension
University of California, Davis

Master Brewers Program
Professional Brewers Certificate Program

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Academic Director and Principal Instructor

“In this industry, there are a lot of people who understand what they’re doing but not why they’re doing it. Because of this program, I’m able to work in a brewery, and if something goes wrong, I understand the science behind it and can use that knowledge to correct it.”

~Aaron Barth, head brewer,
Big Storm Brewery, Odessa, Fla.
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LOCATION
Classes are held at the new, state-of-the-art UC Davis Extension classroom at Sudwerk Brewing Company in Davis. This location allows observation of beer production by Sudwerk's fully automated 65-barrel Steinecker system.

FOR MORE INFORMATION
For general information, call toll free (800) 752-0881 (within the U.S.) or (530) 757-8777 (outside of the U.S.). For more specific program information, call (530) 757-8899 or email brewingprograms@ucdavis.edu.

For the most up-to-date information about these programs, including course dates and class schedule, visit our website.

Photos by Karin Higgins/UC Davis at Sudwerk Brewing Company and the August A. Busch III Brewing and Food Science Laboratory.

extension.ucdavis.edu/brewing
PREREQUISITES
MASTER BREWERS PROGRAM
PROFESSIONAL BREWERS CERTIFICATE PROGRAM

Success in these programs requires a background in biology, microbiology, biochemistry, chemistry, physics, mathematics and engineering topics. Though a college degree related to one of these areas is preferred, it is not necessary for admission to the Master Brewers Program or the Professional Brewers Certificate Program. Nevertheless, because instruction is in strictly scientific terms, some relevant college-level work is required in these areas to assure that students get the most out of their Davis experience. However, the breadth of topics covered in the programs is wide, and few candidates will be adequately prepared in all areas. You should have (a) adequate preparation in mathematics (pre-calculus) and (b) relevant preparation in at least two other areas listed below.

Mathematics — (i.e., pre-calculus); The brewery engineering program does not require calculus for success, but algebra skills are necessary for calculating (e.g., fluid flow and heat exchange). These skills are usually described as “pre-calculus,” meaning the most advanced mathematics course before a calculus course. The engineering program provides ample opportunity for computation, and you should not be intimidated by this.

Biological sciences — (i.e., biochemistry, microbiology or cell biology); Such courses, along with chemistry, are the foundation of our brewing science studies (e.g., malting, mashing and fermentation), which is about two-thirds of the total effort. You should choose courses that are general in approach and include cell structure and function, cell components (e.g., proteins enzymes and carbohydrates) and the biochemical pathways that drive the life of cells. Students with a good biology background should focus on physics/math preparation.

Chemistry — (i.e., a second semester of a general chemistry course or beyond); Inorganic chemistry covering the nature of matter (e.g., atoms, chemical bonds, gases, liquids and solids, solutions, colloids and change of state) is useful. A similar introductory course in organic chemistry is also desirable because most all of the molecules relevant to brewing are organic. Ideally, you should understand nomenclature, structure, bonding/bonds and isomerism of organic molecules, and the properties of functional groups on alcohols, esters, organic acids, aldehydes and ketones as these compounds are important in intermediary metabolism and in beer flavor.

Physics — Physics is a very useful foundation for our engineering courses, and candidates without engineering course experience should complete some physics coursework. Physics courses on heat (temperature and thermal properties of matter and heat transfer) and mechanics (mechanical properties of matter, motion, work/energy, momentum, gas laws) are useful. Courses on electricity, magnetism and light are not applicable. Process control courses are not a substitute for physics courses, but have their own value for parts of the curriculum.

Engineering — Candidates with engineering courses (whether or not a degree was granted) are likely to have adequate physics and math skills and probably a sufficient grasp of chemistry for our program. However, such candidates are often under prepared in biology and should concentrate on biology courses.

All minimum prerequisites must be completed in advance of applying. Incomplete applications will not be considered for admission.

Practical brewing experience is valued because it provides a useful context for learning, but is not required for admission into the programs and will not substitute for adequate preparation in science.

For questions regarding prerequisites, please call (530) 757-8899.

“I cannot put into words how much the Master Brewers Program has benefited me.”
The Master Brewers Program is a unique and intensive program on brewing science (malting, mashing, brewing, fermentation and finishing), brewery engineering (fluid flow, heat and mass transfer, solid-liquid separation) and packaging. The program thoroughly explores these fields through courses that are the professional-level equivalents of UC Davis degree-program courses. The primary goal of the program is to provide you with the fundamental knowledge and insight necessary for employment in the brewing profession at the highest level of responsibility.

Objectives

The primary objectives of the Master Brewers Program are: (1) to enable you to become knowledgeable, thoughtful, accomplished and professional practical brewers who are eagerly sought by employers in today's brewing industry and (2) to prepare you, should you select this option, to pass with confidence the Institute of Brewing & Distilling Diploma in Brewing Examination (IBD DBE).

Students who successfully complete the Master Brewers Program are well prepared to undertake the following tasks alone, as a group leader or as a member of a team:

1. Evaluate and select raw materials for specific brewing objectives and product qualities. Efficiently and safely operate the brewhouse for wort production. Manage yeast and fermentation to meet product objectives, and finish and package the product to contemporary standards of excellence. Conduct a quality assurance program suited to the brewery and product mix.

2. Design a brewery unit, or offer educated input to a brewery design team. Wisely select, or help to select, equipment from among several choices. Oversee installation of it to contemporary standards. Make logical and useful evaluations of processes used in a brewery and select appropriate options.

3. Undertake a wide variety of problem-solving tasks related to product quality, process efficiency or plant design. The well thought out, tightly focused and intense mixture of theory, observation and practice available in the Master Brewers Program is obtainable in few places in the world, and those who complete this program join an elite cohort in the international brewing industry.

Format

The 18-week program comprises three sessions: one 10-week and one four-week, plus a three-week review session. You study brewing science and brewery engineering in parallel courses that include university-level lectures and tutorials. In addition to such directed studies, you expand your brewing knowledge through assigned reading and writing exercises, as well as contact with the brewing community in Northern California and guest speakers as the opportunity arises.
Session 1
The first session is an intensive 10-week introduction to brewing science and brewery engineering, using standard lecture/discussion format. This provides a thorough understanding of fundamentals. Instruction follows a logical progression from barley to beer and works through relevant engineering topics. The intent of the first session is to build a solid framework of understanding of brewing science and technology and the scientific boundaries within which successful brewing is done. The engineering program introduces essential engineering principles relative to brewing processes and equipment design. The first session comprises daily lecture sessions of up to six hours per day, four days per week; the fifth day is dedicated to review and examinations.

Session 2
The second session of the program is four weeks and addresses the same topics in greater depth and in discussion format and uses additional instructional strategies, including observations in working breweries, tutorials, guest speakers, research and extensive reading and writing assignments. Old questions from the DBE are frequently used to stimulate thought, critical analysis and discussion at a high level of competence. This is excellent experience in clear thinking and communication. The objective is to build on the fundamentals explored in the first session and to acquire a mature understanding of the brewing process as a unified whole, with emphasis on the relation of raw materials and processes to product quality. The engineering program similarly reviews the topics of the first session and introduces an additional range of topics. In this session, instructional days are somewhat shorter to provide time for private study.

Session 3
This session ends the period of formal instruction with a three-week overview of the course taught in lecture format. We also welcome a few new students for whom these three weeks are preparation for the IBD Diploma in Brewing Exams. Little new knowledge should be introduced at this stage. You will focus on manipulation of the knowledge already gained, a deeper understanding of it, expressing ideas in written form and developing a seamless relationship between theory and practice.

Instructional Outline
The following outline is a general guide to the format and content of the program. The precise program curriculum will be tailored to the needs of the class as it develops.

First Session (10 weeks)*
(a) Brewing Science: Barley to Malt; Malt to Wort; Wort to Beer (UNEX-X402.1)
(b) Brewery Engineering: Physical Principles in Brewing and Packaging Technology (UNEX-X403.1)
(c) Weekly Examinations
*This first session completes the Professional Brewers Certificate Program. See page 8.

Second Session (four weeks)
(a) Brewing Science: Linkages and Relationships; Brewing Processes and Beer Quality
(b) Brewery Engineering: Quantitation and Calculation

Third Session (three weeks)
(a) Brewing Science: Materials and Wort-DBE Module 1
(b) Brewing Science: Yeast and Beer-DBE Module 2
(c) Brewery Engineering: Packaging and Process Technology-DBE Module 3

Diploma in Brewing Examination
Dates scheduled by the IBD. Generally the first week in June.
At the end of the first session, you should have a sound understanding of the following topics at the level of a fine journeyman brewer. This level of understanding should be adequate for solving most practical problems and resolving most day-to-day issues that arise in a brewery context. You should have the ability to work independently in a brewery environment under the leadership of a more educated and experienced brewer. The first session provides a solid base for further education and training in the field.

**BREWING SCIENCE AND TECHNOLOGY (UNEX-X402.1)**

**Brewing Science: Barley to Beer**

Gain a thorough understanding of the science and technology of ale and lager brewing and become familiar with the specialized language and concepts of the brewing industry. This is accomplished by a sequential study of brewing raw materials, brewing processes and quality control methods of the industry and their influence on beer character. This recurring theme illustrates the scientific and practical confines within which successful brewing is performed. When you complete the first session, you will have a good understanding of what constitutes beer quality and how this is achieved by contemporary methods of manufacture.

**Topics include**

- The history of brewing. Brewing and beer around the world. Overview of the process from barley to malt. A review of basic science relevant to brewing.
- Technology of malting from selection of barley to preparation of specialty malts. Biochemistry of malting and malt quality and analysis. Malt handling, mills and milling.
- Technology of production of hops and hop products. Hop chemistry. Kettle boil.
- Yeast propagation and handling. Fermenters and technology of fermentation.
- Finishing and filtration. Carbonation and stabilization of beers, beer analysis and quality control methods.
- Sensory analysis of beers.

**Format**

Up to 25 hours per week of instruction; five days a week for 10 weeks.

**Brewing exercises**

You will have the opportunity to view some of the principles covered in the first session by observing brewing at Sudwerk Brewing Co., visiting local breweries and at beer tastings. However, there will be insufficient time for significant hands-on teaching and learning outside of classroom lectures.

**BREWERY ENGINEERING (UNEX-X403.1)**

**Physical Principles in Brewing**

Learn the physical and engineering principles that have important applications in the brewing industry, including: fluid-flow (through pumps, pipes and valves); properties of steam, energy balances, heat transfer and refrigeration (in boilers, calandria, heat exchangers and refrigeration plant); and the gas laws (carbonation and dispense). The objective is to ensure that you can hold an intelligent discussion with engineers and can evaluate engineering proposals.

**Topics include**

- Physical principles of engineering.
- The properties of steam, including phase diagrams and steam tables. Conservation of energy. Energy balance.
- Fluid flow, measurement, streamline/turbulent flow, valves, pipes and pumps.
- Pressure, volume and temperature relationships. Carbonation.
- Modes of heat transfer: conduction, convection and radiation.
- Refrigeration.
- Packaging.

**Format**

Up to eight hours per week of instruction.

**Engineering exercises**

You will compute solutions to typical engineering problems that arise in breweries, and examine equipment that illustrates the principles discussed in the lecture material.
SESSION 2 CURRICULUM
MASTER BREWERS PROGRAM

At the end of the second session, you will have a solid understanding of the topics listed below at the level of a master brewer. This level of understanding should be adequate for solving all practical problems and day-to-day issues that arise, and for providing outstanding technological leadership in a brewery context. Upon completion of the second session, you will be prepared intellectually to take on significant responsibility for a brewery and provide the technological guidance required for successful operation.

BREWING SCIENCE
LECTURE AND TUTORIAL

Linkages and Relationships; Processed Beer Quality
From further study of the subject matter in this session, which expands considerably on the somewhat uni-dimensional approach of the first session, you will gain an in-depth theoretical knowledge and intimate practical understanding of malting and brewing raw materials, brewing processes and product quality. You will now appreciate beer-making, not as an assembly of individual actions, but as a fully integrated interlinked and holistic enterprise. This is done by exploring chosen themes or issues in brewing that are of both practical and theoretical consequence, taking special note of the interdependence and multifaceted aspects of these issues across the whole spectrum of process and quality. The focus of the lecture and tutorial course is to provide a sophisticated appreciation of the subject matter at a top professional level and also appropriate for those opting to take the IBD DBE. At the end of this session, you will be able to think and act over a broad spectrum of brewing knowledge to evaluate and elucidate problems, have a firm grasp of what is known and what is assumed, and develop a healthy regard for the difference.

Topics include:

- Malt, malting processes and malt components in wort and beer and their role in beer quality with special focus on haze, foam and microbiological stability. The non-volatile components of beer and their origin in the biochemistry of malt, their modification by process decisions and their role in beer quality.
- The chemistry of hops and their measurement and the role of hop compounds in beer quality, including flavor, foam and stability. Brewing water and brewing calculations (e.g., for beer formulation and for adjustment of brewing water).
- Wort production: the chemistry of carbohydrates. The spectrum of these compounds present in worts and beers and their origin and role in product quality. Extract yield and the variables that influence it (e.g., milling, mash thickness, mash temperature and solid-liquid separation). Wort stabilization and composition relative to yeast nutrition.
- Yeast and fermentation: the yeast cell, fermentation and fermenter design, yeast physiology, normal and abnormal beer flavors and their relation to wort composition, beer quality and the brewing processes that produce them. Evaluation of yeast quality and amount and its relation to consistent fermentations.

Format
10-16 hours weekly, over four days per week.
BREWERY ENGINEERING
LECTURE AND TUTORIAL

Brewery Engineering; Quantitation and Calculation

Further explore the physical and engineering principles introduced in Physical Principles in Brewing (UNEX-X403.1). Although the course is concerned with concepts, computation is a major theme applied to the solution of realistic problems, including brewing equipment design. Special attention is given to those aspects of engineering that are important in breweries, such as fluid flow. New topics are also introduced as required by the engineering curriculum of the IBD, including psychometrics and solid-liquid separations (filtration). The objective is not to make professional engineers, but to ensure that you can hold an intelligent discussion with engineers and can evaluate engineering proposals.

Topics include
- Materials handling and size reduction (milling).
- Heat transfer.
- Solid-liquid separation and filtration performance.
- Pumps, pipes and fluid flow. Friction factors. Rheology.
- Refrigeration.
- Packaging.

Engineering exercises

Compute solutions to typical problems that arise in breweries and examine equipment and demonstration devices designed to illustrate the principles discussed in the lecture material.

Format

Six to nine hours per week of lecture and computation workshops.

“The Master Brewers Program was an incredible academic experience because of the world-class professors who are at the peak of their profession.”

~Sam Hartwell
SESSION 3: REVIEW SESSIONS
MASTER BREWERS PROGRAM

“Review and revise” and “question and answer” are the objectives of these last three weeks (five days per week). No new material should be introduced during this time as we assume you are fully familiar with the material. For those who opt to take the Institute of Brewing and Distilling Diploma in Brewing Examination (and for those who join the program at this stage), this is the final opportunity to ensure you have a mature and confident grasp of the information and can communicate it clearly in written form and in calculations.

Review Session 1 IBD-DBE-1
Malts, malting processes, malt quality and beer. Brewhouse operations, wort production and beer quality.

Review Session 2 IBD-DBE-2
Yeast, fermentation and finishing and beer quality. Quality control techniques and waste streams.

Review Session 3 IBD-DBE-3
Material of construction, combustion, instrumentation and process control. Fluids and mass transfer. Heat transfer, refrigeration and psychometrics.

Format
Meet daily for up to six hours to review topics primarily in lecture format. The evenings will be free for independent study.

The Diploma in Brewing Examination (DBE)
Many students complete their Master Brewers Program education at UC Davis by taking the demanding Institute of Brewing and Distilling Diploma in Brewing Exam (IBD DBE) for which the Master Brewers Program is excellent preparation. Passing the examination is an internationally recognized standard of achievement and professional qualification for practical brewers, managers and executives in breweries and malting and allied industries. This challenging nine-hour, three-part examination, consisting of two papers in brewing science and one in brewery engineering, is administered annually to more than 300 candidates worldwide.

The examination is written and graded by a distinguished panel of brewing academicians, brewery scientists and engineers selected by the IBD and impaneled as the Board of Examiners. The examination is held each year in June, immediately following the Master Brewers Program. UC Davis is an approved examination site.

“I started out hoping just to pass the Diploma in Brewing Module Three Exam, but with the instructor's help I was able to win the Brewery Engineers Award for achieving the top passing mark—an achievement that would not have been possible without the expert teaching I received.”

~Scott Stokes, brewing manager, Columbia Brewery
OVERVIEW

PROFESSIONAL BREWERS CERTIFICATE PROGRAM

This intensive 10-week program meets six hours a day, five days a week and is taught simultaneously with the first 10 weeks of the Master Brewers Program. Through lectures, the program provides you with a solid understanding of brewing science and engineering. Student learning is measured through weekly exams and written exercises. Individuals who successfully complete the program are awarded the Professional Brewers Certificate and earn 24 units of academic credit.

Objective
The certificate program is designed to provide a legitimate, university-approved qualification to individuals who wish to enter the brewing industry, as well as to serve brewery personnel with no formal scientific training and wish to seek appropriate education to advance their careers.

The program provides students with an understanding of:

- Grain handling, malting, malt analysis and the effects of these in brewing
- Brewhouse processes and the control of wort quality as a result
- Yeast and fermentation processes and their effects on beer quality
- Beer filtration and finishing and packaging (introduction)
- Flow of fluids in pipes and through pumps in a brewery setting
- Heat transfer through flat and curved surfaces and the effects of insulation and fouling on efficiency
- Theory and practice of carbonation including mixed gas technology
- Theory and practice of refrigeration in the brewery

Prerequisites
Please refer to page 1 for detailed information regarding prerequisites.

“UC Davis Extension has the best program in terms of background knowledge and the caliber of professors teaching it, and it is the most extensive and intensive in the engineering side of things. I owe where I am to this program. It really helped get me on a career path, not just a job, a lifelong brewing career.”

~Kevin Wright, founder and brewmaster, Third Space Brewing, Milwaukee, Wis.
This program is taught simultaneously with the first 10 weeks of the Master Brewers Program. At the end of this program, you will have a sound understanding of the following topics at the level of a fine journeyman brewer. This level of understanding should be adequate for solving most practical problems and resolving most day-to-day issues that arise in a brewery context. You should have the ability to work independently in a brewery environment under the leadership of a more experienced brewer. This certificate program provides a solid base for further education and training in the field.

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**Topics include**

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- Modes of heat transfer: conduction, convection and radiation.
- Refrigeration.
- Packaging.

**Format**

Up to eight hours per week of instruction.

**Engineering exercises**

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To Apply
Complete application packages must include a completed application form, transcripts supporting the academic prerequisites (unofficial transcripts are acceptable), a résumé listing any practical experience in brewing or a related field, and the application fee of $45.

Applications are reviewed and accepted on a first-come, first-served basis. Class size is limited so early application submission is encouraged.

Apply online at: extension.ucdavis.edu/brewing.

Student Services
Library Card
Participants in the Master Brewers Program and Professional Brewers Certificate Program will be issued a library card application on the first day of the program.

Activities and Recreation Center
A pass allowing use of the Activities & Recreation Center (ARC) can be purchased by the day, month or quarter.

Financial Assistance
While participants in the Professional Brewing Programs are not eligible for financial aid based on the FAFSA, you may be eligible for a tax credit for educational expense, job training funds, alternative student loans or other financial assistance.

Student Loans
Students enrolled or planning to enroll in a program or series of courses at UC Davis Extension can apply for a private alternative student loan, available to students not enrolled in a degree program. It is recommended that you begin the loan application process early as UC Davis Extension does not enroll students in courses until payment is received, and applying for a loan does not reserve a space in the course.

Housing in Davis
Finding housing in Davis can be difficult because the vacancy rate is quite low and there is strong competition for all available rentals. While we will do what we can to assist you in finding housing, we strongly encourage you to act as early as possible.

Options and average rates
A private room in a house with kitchen privileges: $700/month and up
1 bedroom apartment/house: $1,200/month and up
2 bedroom apartment/house: $1,500/month and up
3 bedroom apartment/house: $1,800/month and up
4 bedroom apartment/house: $2,300/month and up
6 bedroom apartment/house: $2,800/month and up

Most houses and apartments in Davis are leased on an annual basis, from September 1 through August 31.

Some apartments or houses are furnished, but most are rented unfurnished. Basic furnishings can be purchased either new or used from several businesses in the area.