

# **EXECUTING THE CBE 4590 DESIGN PROJECT**

**2022-2023 Academic Year**

When planning to undertake your senior design projects, the following items need to be addressed. Please read this document thoroughly shortly after receiving your design project assignment and keep it in mind throughout the course.

This year's projects are very promising and, hopefully, will lead to novel, interesting and profitable designs. Good Luck!

## **1) OVERVIEW**

The projects are developed for the class by faculty, students and industrial consultants. The goal is to have interesting and potentially economically favorable projects. Note that when the economics are found to be unfavorable, which often occurs in industry, the results are still useful in guiding a company's ongoing strategy. There is no stigma in this course if the economics are unfavorable, as long as the design and analysis are well done. Economics is important but only one leg in the 3-legged sustainability stool.

## **2) SOURCES OF INFORMATION**

Your project author is your first source of information and data. However, usually, all the data your team will need is not readily available and you will be given guidance as to where to look or what assumptions are reasonable when some important data are unavailable.

Your faculty advisor, Prof. Vrana and industrial consultants will do their best to help in your search for data or in formulating assumptions. For each project, some faculty and consultants will be more knowledgeable. Others may have more limited knowledge of the technologies but will try to help in the overall project development.

## **3) FALL DESIGN GROUP MEETING**

Each design group will meet with its project author, faculty advisor and Prof. Vrana in October to raise questions and obtain suggestions regarding the formulation of a solution strategy. The purpose of this meeting is to review your research to date, answer any questions you have about the project, and plan the next steps. It is your responsibility to find a time and location that works for your entire group, your faculty advisor, project author and Prof. Vrana. Industrial consultants and Prof. Vrana will likely participate via Zoom, but everyone on campus should meet together if possible. Do not wait until the last minute to schedule this meeting as everyone has busy schedules, and Prof. Vrana needs to attend all group meetings. Use a registered Zoom account to send the Zoom invitation. Do not use the "Only authenticated users can join" setting in Zoom, since most problem authors do not have a Penn e-mail address.

In addition to this meeting with your problem author, faculty advisor and Prof. Vrana, your team should meet as needed to establish a tentative schedule for the project (which should be updated as needed), establish goals, plan tasks and prepare for the fall presentation. Your team will need to decide how best to organize and self-manage your project.

On each of three Monday evenings (**Nov. 21, Dec. 5, Dec. 12**), three or four groups (plus CBE students working on ISD projects) will describe their plans to the entire class with a 15-minute presentation. Approximate flows of the major streams on a block flow diagram should be included. You should show that you have begun thinking about the project, who your customers are, the market you are entering, what the manufacturing process involves, some of the problem challenges, etc. The presentation should include, at a minimum:

- Description of your project and why it is interesting
- A block flow diagram of your process, preferably with approximate flows
- How you are planning to organize your work
- Tentative schedule
- What are the public health, safety, environmental or societal impacts associated with your project
- What new knowledge you need to acquire and apply to successfully complete your project
- Path forward

#### **4) SPRING DESIGN GROUP MEETINGS**

Per the attached project and consultant schedules, on Tuesday afternoons, your group will meet with one or more industrial consultants and your faculty advisor. Periodically, Prof. Vrana will attend your meeting as well. There will be 10 weekly one-hour meetings with the industrial consultants, and groups should prepare to get what information or advice they need each week. Note that you will meet with different consultants from week to week, and that the schedule occasionally needs to be changed to meet their availability.

All weekly meetings will be held in the Weiss Pavilion (under the north stands of Franklin Field) – Conference Rooms 225, 226 or 235 of the Penn Libraries Education Commons. Each room is equipped with a large-screen LCD for screen sharing, and a networked computer. You can also project your own computer to the LCD if you have an HDMI port. If you have a Mac, you might purchase a Lightning-to-HDMI adapter. The computers in the rooms do not have cameras, microphones, or speakers. Please bring any necessary files on a flash drive or have them readily available by logging in to the network.

Because some consultants do not live near Philadelphia, some weekly meetings need to include participants on Zoom. We have grouped all consultants who usually require Zoom together, to reduce the number of meetings with both Zoom and in-person consultants. However, due to travel or illness, any weekly meeting might need to also be Zoom-friendly. If your meeting requires Zoom, it is your group's responsibility to schedule it using a registered Zoom account and invite the scheduled consultants. Do not use the "Only authenticated users can join" setting in Zoom, since the industrial consultants do not

have Penn e-mail addresses. You should still present on the large screen TV so that everyone in the room can see – perhaps by also logging into Zoom on the desktop computer in the room.

Consultants, your faculty advisor and Prof. Vrana will be better able to help if you provide a handout with the current state of your process flow diagram or flowsheet and other key information. Printed handouts are best if you are meeting in person. Be sure to e-mail appropriate files to all remote participants and Prof. Vrana.

For your first design group meeting in the spring, on January 17, be prepared to present your *objective-time chart* in writing, as described on page 8 of SLSWGN. Also, show your initial work on an *innovation map* for your product design (see pp13-14). In addition, show the initial results of your market and competitive analyses and indicate customer requirements (pp10-12).

Then, if a process is being designed, discuss your findings, thus far, concerning:

- a. A survey of the methods used in manufacturing the product, giving the raw materials, the principal chemical reactions, byproducts, and intermediates.
- b. A discussion of the choice of the production level and plant location.
- c. A block diagram showing the principal steps for the process anticipated to be the most promising (Figure 2.16 – p42). When possible, prepare promising process flow diagrams (Figure 2.17 – pp42-44)
- d. Reaction kinetics and thermophysical property data.
- e. Economics, toxicity, and safety data (pp20-21).

These materials should be updated and presented every Tuesday, with one copy provided for your faculty advisor and the industrial consultants who meet with you. Also, please give or e-mail a copy to Prof. Vrana, whether he attends your meeting or not. Please check the consultant schedule each week, and bring copies for everyone expected to attend, and e-mail copies to remote attendees. An extra printed copy would be a good idea, to accommodate any unforeseen changes in the consultant schedule

The weekly meeting is your opportunity to update your faculty advisor, Prof. Vrana and the industrial consultants of your current status and then ask any questions that you have. Everyone in the group should present what they have done in the past week and ask any questions you may have. This is your hour to seek advice from experienced engineers – use it well. If the group before you is running over time, you should diplomatically encourage them to wrap up. Minimize the time it takes to set up technology by knowing in advance which computer you will use for Zoom (if needed) and projecting on the large screen, ensuring you have any necessary adapters, files, etc. You should test your technology in the Weiss Pavilion before the first weekly meeting, so you don't lose valuable meeting time working out the technology.

The “Monday” before the first weekly meeting, this year Wednesday Jan. 11, we will hold a lecture at 5:15 to review the process for the weekly meetings and answer any questions

you have. All students should attend. There will be two other Monday lectures early in the semester: one to discuss writing the design report and a second to discuss engineering considerations as well as economics. ISD groups working on CBE-heavy projects that meet with our industrial consultants are encouraged to attend all lectures, except for the one focusing on the design report.

## 5) **PROGRESS MILESTONES**

Attached is a schedule of the weekly design group meetings on Tuesday afternoons in the spring. Milestones indicate items suggested to be prepared for specific meetings. Items that say "Submit" should be handed to or e-mailed to Prof. Vrana. Every project is different, but these milestones should be general indications of progress. In cases where the milestones don't apply to your project, modifications should be formulated by your group and agreed upon with your faculty advisor and Prof. Vrana. Monday lectures are also listed in the Milestones column.

Your preliminary mass balance and block flow diagram should be completed and submitted to Prof. Vrana by the third week of meetings. For a product, focus on the customer preferences, the technical specifications, the product concept, and a competitive (patent) analysis (Section 1.2 - SLSWGN.)

Most of the process synthesis work should be completed by week 5 or 6. Plan to review the material and energy balances for the most promising flowsheet(s), that is, base-case designs, together with a computer-drawn process flow diagram. See *Flow Diagrams* in Section 2.5 (pp41-44 - SLSWGN).

Much of the detailed design of your new product and/or the process units for your manufacturing plant should be completed by the 8<sup>th</sup> consultant meeting. Plan to discuss the detailed design for your product or process and key process units. All equipment should be designed the week after that, and economics completed by the final meeting with industrial consultants.

Additionally, a revised schedule should be given or sent to Prof. Vrana every few weeks as indicated on the weekly schedule. Each time, it should be updated to show the timeline for the major tasks completed, underway and for the rest of the semester. Needing to revise the schedule (or mass balance or anything other work) to reflect progress to date is normal, perfectly acceptable and far better than ignoring issues.

The intent here is to pace each group in completing its project and final design report without undue stress and time limitations toward the due dates. You will regret falling behind schedule.

## 6) **LIBRARIES**

Learn to use the SEAS Library Collection and the Chemistry Library effectively. To help, our librarians, Douglas McGee and Judith Currano, have prepared a discussion of the

special features of the SEAS and Chemistry Libraries, use of the important indices, computerized databases, and facilities for interlibrary loans. They will make presentations in a CBE 4000 Monday evening class in the fall. Also, you may find the *Design Literature* in Section 3.1 (SLSWGN) helpful.

## 7) WEEKLY PROGRESS

As your design evolves, individual team members should assume responsibility for aspects of the work. It is important that your group meet from time-to-time during the week to examine each other's work and coordinate the next steps.

At Tuesday meetings during the spring semester, each student in the group should be prepared to discuss aspects of the work for which they are responsible. Use the group meetings to discuss results and seek advice. Participation will influence your grade. These meetings will be attended by your faculty advisor and one or more industrial consultants. Prof. Vrana will attend your group meeting for the full hour every third week. Your weekly meeting should be prepared to keep your faculty advisor and Prof. Vrana abreast of your progress. These reports should describe your efforts completed during the prior week, provide process flowsheets, and raise questions and concerns, among other items. Printed copies of relevant materials – particularly block flow diagrams or process flow diagrams and material balances - should be presented to your faculty advisor and your industrial consultant(s) in attendance at your meeting. Also, when Prof. Vrana doesn't attend your meeting, please find him at the Weiss Pavilion and hand him a printed copy or send e-mail. It is to your advantage to update Prof. Vrana every week, so he can better answer questions or help your group with any issues.

Between Tuesday design meetings, you can seek help from your advisor, Prof. Vrana, other faculty with specific expertise, the project author, the industrial consultants, other industry contacts as recommended, etc. Our industrial consultants all have busy schedules. Please contact them only after exhausting other avenues for help. When contacting anyone in industry not associated with this course, such as equipment vendors, be sure they understand that your questions concern your **senior design project**. Note that Prof. Vrana is experienced in the design of many industrial processes. He will try to provide help in all areas of your design project, but cannot be fully aware of all possible technologies. When necessary, he will refer you to someone better able to help.

## 8) OFFICE HOURS

Prof. Vrana will be available for meetings as needed. He will schedule office hours at different times every week in the spring. You can also request a Zoom meeting as needed. Please suggest a few times that will work for your team via e-mail, and he will try to find a mutually agreeable time. Evenings or weekends are generally more available than daytime, and afternoons are more available than mornings.

In addition to meetings, Prof. Vrana encourages e-mail. He is usually available with little delay, and keeps an eye on Penn e-mail throughout the day and evening. Many questions

can be handled by e-mail, so do not hesitate to ask technical or non-technical questions. If something is holding you up, please ask about it rather than waiting until the next Tuesday meeting. Remember, however, that he has a full-time job at IFF in Wilmington, Delaware, so daytime responses may be delayed at times, depending on the type of question asked and the time required to formulate a response.

## 9) **15-MINUTE ORAL PROGRESS REPORTS**

On Tuesday, February 28, during your normal group meeting hour, your design group will make a 15-minute oral progress report to your design group faculty advisor, and Profs. Vrana, Fabiano, and Seider. Industrial consultants and other project authors will also be invited. You are expected to stay for the entire hour, listen to presentations by the other groups, and offer feedback as appropriate. You may get feedback or ideas from other groups that will help your project. Further details will follow in the spring.

## 10) **SOFTWARE AVAILABILITY**

Feel free to use Aspen Tech's Aspen Engineering Suite (including ASPEN PLUS, ASPEN PLUS DYNAMICS, ASPEN BATCH PROCESS DEVELOPER (formerly BATCH PLUS), and ASPEN PROCESS ECONOMIC ANALYZER (formerly Aspen IPE, formerly Aspen Icarus), SUPERPRO DESIGNER, the equipment costing spreadsheet, the Downey Economics Spreadsheet (Profitability Analysis 4.0.xls), VISIO Technical Plus, MATLAB, GAMS, ProPred, and ProCAMD. These programs can be accessed from the computers in the Towne computer labs or by remote desktop.

For those groups that use Aspen Tech products, Prof. Fabiano can be very helpful. Also, he can help you with the detailed design of specific equipment items and provide advice on the application of the SUPERPRO DESIGNER batch process simulator.

Since most industrial companies use Microsoft Office, you will likely need to be proficient in Office products post-Penn. You are therefore encouraged to take advantage of licenses to Microsoft products that Penn provides. The spreadsheets provided for the course have error-checking and password protection to ensure the accuracy and integrity of the calculations. Unfortunately, other spreadsheet software does not always work with these safeguards, and thus is discouraged.

## 11) **WRITTEN AND ORAL DESIGN REPORTS**

Your written design report is due on Tuesday, April 11 to your faculty advisor. It should follow the format in Chapter 23 (*Written Reports and Oral Presentations* – SLSWGN) and the Monday evening lecture on the design report early in the spring semester. The report will be reviewed by your advisor and returned to you with comments before Friday, April 14. It is your responsibility to discuss (or negotiate) these dates with your advisor to ensure you get feedback on the timeline you need. You will make revisions and submit your revised written report by 5:00 p.m. on Tuesday, April 18, in both paper and PDF form. Please plan ahead and get your report to the Towne Printing Office on Monday, April 17.

Note that a lecture has been scheduled on Monday, January 30 at 5:15 p.m., to provide advice in the preparation of your design report. We will go over Chapter 23 and clarify any questions you may have. All students should plan to attend. Also, the design reports will be electronically published as PDF files in Scholarly Commons for posterity (see [http://repository.upenn.edu/cbe\\_sdr/](http://repository.upenn.edu/cbe_sdr/)).

Oral design presentations will be on Tuesday, April 25. Each group will be allotted 40 min (30 min presentation, 10 min questions). We will have an **All-day Technical Meeting** involving students, faculty, and consultants. **Lunch** will be provided at approximately noon, with the **Senior Class Picture** taken just prior to the luncheon. You are expected to be present and participate for the entire day, except when attending other classes, to support and celebrate the accomplishments of your classmates. Further details will follow in April.

## 12) TEAMMATE EVALUATION

You will complete two survey questionnaires during the semester in which each design team member will be asked to assess the percentage effort on the project by all team members including himself/herself. Each group member will be required to provide an evaluation of other team members' performance and participation quality. This will be required at the halfway point of the semester and again after the presentations are completed – and may have an impact on individual grades. It is not expected that all group members will contribute exactly the same percentage of the work, but reasonable percentages are expected.

## 13) COURSE GRADES

Your faculty advisor will read your draft report and suggest changes. Then, Prof. Vrana will read all the final reports written by the CBE design groups and will provide detailed comments on your final report. The final written and oral reports, and participation and presentation at weekly design group meetings will determine your final grade. Grades for your oral design presentation will be suggested by those in attendance. Then, Prof. Vrana will determine your course grade, with the concurrence of your faculty advisor.

## 14) MOLSTAD/SEIDER PRIZE

The three winning groups of the Melvin C. Molstad/Warren D. Seider Prize, for the most outstanding CBE designs, will be honored during Commencement Exercises and receive a cash prize.

## 15) EAS COMPETITION

The annual Engineering Alumni Society competition for all SEAS departments is typically held the Friday after final CBE presentations. Typically, the top 3 groups are invited to present, unfortunately with only a few days to prepare. The details have not yet been decided for 2023. However, last year, groups that were presenting needed to submit a brief recorded video before CBE awards were decided. CBE groups that wanted to present, if

they won the CBE awards, were required to submit a video by the Sunday before their final CBE presentation. This process could be the same or different this year. Details will be passed along as they become available in the spring.

## **16) SPRING COURSE REGISTRATION**

CBE 4590 has two sections with a three-hour lecture on Tuesday afternoon: 1:45-4:45 and 3:30-6:30. We have scheduled your meeting time around your known time conflicts as well as the availability of your faculty advisor. Groups that meet at 1:45 and 2:45 should register for the 1:45 section. Groups that meet at 3:45 and 4:45 should register for the 3:30 section. If you find you have a required course whose only section conflicts with the one-hour meeting scheduled, you must inform Prof. Vrana ASAP and definitely by the end of spring registration in mid-November. If possible, we will then swap your meeting time with another group, but this may not be possible in all cases. However, once spring registration is complete, we will consider the meeting schedule final and no changes will be possible, as it would be disruptive to other groups. If you have a course conflict with the 3-hour lecture that does not overlap with your meeting time (for example, a 1:45-2:45 meeting time, putting you in the 1:45-4:45 section, and a required 3:30 course), Prof. Vrana will gladly sign the course conflict form allowing you to register for both courses.