EXECUTING THE CBE 4590 DESIGN PROJECT

2024-2025 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, if the design and analysis are well done. Economics are 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, 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 MEETINGS

Each design group will meet twice during Monday recitations on **October 21** and **November 4**. Groups should decide how they will organize themselves, establish goals, plan tasks, and find suitable meeting times outside of class. Groups should also work on technical aspects of their design, particularly items required for the fall presentation, and formulate questions for their problem author (or industry proxy, for student-written problems). Additionally, groups should establish a schedule for their project, including tasks, which should be updated as needed throughout the project.

Each group will meet twice with their author (or industry proxy), faculty advisor and Prof. Vrana in the fall. One meeting needs to be held between the two recitations (so **between October 22 and November 3**), and the other needs to be held after the second recitation and before the fall presentation (**between November 5 and 15**). The purpose of these meetings is to review your research and work to date, answer any questions you have about the project, obtain suggestions regarding the formulation of a solution strategy, and plan the next steps.

It is your responsibility to find times that work for your entire group, your faculty advisor, project author and Prof. Vrana. It is strongly recommended that you use When2meet.com (or a similar app) to find suitable meeting times. You should contact all parties to schedule those meetings within a week of the announcement of the groups. Industrial consultants and Prof. Vrana will participate via Zoom. Use a registered Zoom account to send the Zoom invitation. Do not use the "Only authenticated users can join" setting in Zoom, since industrial consultants do not have a Penn e-mail address.

4) FALL PRESENTATION

On two Monday evenings (**Nov. 18 and 25**), three groups (plus CBE students working on ISD projects) will describe their project to the entire class with a 20-minute presentation. You should show that you have begun working on 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
- An initial mass balance, showing feed, product and coproduct flowrates, at a minimum. Excel is suitable for this mass balance.
- Balanced reactions, including side reactions
- How you are planning to organize your work
- Tentative schedule and tasks
- 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

5) 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. Generally every third week, Prof. Vrana will attend your meeting as well. There will be 9 weekly one-hour meetings with the industrial consultants, and you should prepare so that you get what information or advice you 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 face to face 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 HMDI 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.

Due to distance, Prof. Fabiano will usually participate via Zoom. Groups should send invitations to him when he is listed on the schedule. Also, Adam Brostow will meet with group 7 via Zoom as his schedule permits. The group should confirm with him each week whether he is available to meet and send an invitation. A registered Zoom account should be used. Do not use the "Only authenticated users can join" setting in Zoom, since the industrial consultants do not have Penn e-mail addresses. To avoid any doubt, even with one participant on Zoom, everyone else should meet in the Weiss Pavilion.

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, with a copy sent to Zoom participants (via e-mail or meeting chat).

Each week, you should 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 discussed every Tuesday, with a 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. It is to your advantage to update Prof. Vrana every week, so he can better answer questions or help your group with any issues. Please check the consultant schedule each week, and bring copies of important documents, such as block flow diagrams, for everyone expected to attend. 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 discuss what they have done in the past week and ask any questions. 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 to project on the large screen, and for Zoom (if needed), 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 is a holiday this year. The first Monday schedule of the semester will be Wednesday **January 15**, and there will be 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 three other Monday lectures early in the semester: one to discuss writing the design report, one to discuss engineering and equipment, and one to discuss economics and profitability analysis.

6) 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. These items are not graded, but are intended to keep Prof. Vrana up to date with your progress. Items that do not say "Submit" are simply suggested milestones for your group to consider. 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. Most of the process synthesis work should be completed by week 5. 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 of the textbook).

Much of the detailed design of the process units for your manufacturing plant should be completed by the 7th consultant meeting. Plan to discuss the detailed design for your process and key process units. All equipment should be designed the week after that, and economics completed by the final meeting.

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 any other work) to reflect progress to date is normal, perfectly acceptable and far better than ignoring issues.

The intent here is to pace your group in completing the project and deliverables without undue stress and time limitations toward the end. You will regret falling behind schedule.

7) 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 class in the fall. Also, you may find the *Design Literature* in Section 3.1 of the textbook helpful.

8) 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. Tuesday afternoons should not be the only time the group meets.

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 work accomplished in the past week, important results and raise questions and concerns. Participation will influence your grade.

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.

9) OFFICE HOURS

Prof. Vrana will be available for meetings as needed. Rather than scheduled office hours, recent classes have preferred scheduling a Zoom meeting on demand 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 contact via 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 (or research) a response.

10) 15-MINUTE ORAL PROGRESS REPORTS

On Tuesday, **February 25**, during your normal group meeting hour, your design group will make a 15-minute oral progress report to your faculty advisor and Prof. Vrana. 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 ask questions or 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.

11) SOFTWARE AVAILABILITY

Useful software is available on the computers in the Towne computer labs or by remote desktop: Aspen Tech's Aspen Engineering Suite, which includes 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; MATLAB; GAMS; ProPred; and ProCAMD. Excel spreadsheets for equipment costing and Profitability Analysis will be available in Canvas.

For those groups that use Aspen Tech products, Prof. Fabiano is an invaluable resource. 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 work with these safeguards, and groups have run into problems in the past by using spreadsheets other than Excel. Microsoft Visio is an excellent tool for creating professional-looking process flow diagrams, and a template with icons for many types of equipment will be in Canvas.

12) WRITTEN AND ORAL DESIGN REPORTS

Your written design report is due on Tuesday, **April 8** to your faculty advisor. The report will be reviewed by your advisor and returned to you with comments by Friday, April 11. 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 final written report by 5:00 p.m. on Tuesday, **April 15**, in both paper and PDF form to Prof. Vrana. Please plan ahead and get your report to the Towne Printing Office on Monday, **April 14**.

Note that a lecture has been scheduled on Monday, **January 29** at 5:15 p.m., to discuss the format of your design report and provide advice in its preparation. We will go over Chapter 23 of the textbook, 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/).

Oral design presentations will be on Tuesday, **April 22**. 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.

13) 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.

14) COURSE GRADES

Your faculty advisor will read your draft report and suggest upgrades to you. Then, Prof. Vrana will read all the final reports written by the CBE design groups and will provide detailed comments on your final report and a report grade. The final written and oral reports, and participation and presentation at weekly design group meetings will determine your course 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.

15) 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 and receive a cash prize. Winners will be announced the day after final presentations.

16) EAS COMPETITION

The top three groups are invited to participate in the annual Engineering Alumni Society competition for all SEAS departments. Prerecorded videos, due **April 25**, as well as live presentations on **May 2** will determine the winners. Because groups from all majors participate and are judged by engineers from all disciplines, videos and presentations need to be significantly different than the CBE presentations. Details will be passed along as they become available in the spring.

17) SPRING COURSE REGISTRATION

New this year, CBE 4590 has three one-hour recitation sections corresponding to the hour your meeting is scheduled. We have scheduled your meeting time around your known time conflicts as well as the availability of your faculty advisor. 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, the meeting schedule will be final and no changes will be possible, as it would be disruptive to other groups.

You must also sign up for the Monday evening lecture. We plan to only meet on 4 Mondays as shown on the weekly schedule, but all students should be present for all sessions. If an issue that necessitates another lecture meeting arises, it will be announced as far in advance as possible.