

**PRAIRIE VIEW A&M UNIVERSITY
ROY G. PERRY COLLEGE OF ENGINEERING
DEPARTMENT OF CHEMICAL ENGINEERING
CHEG 4304 PROCESS DESIGN AND ANALYSIS
FALL 2021**

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[Include any other evaluation used and omit any method above method (Test, Quizzes, Homework, Laboratory and Project reports) that was not used]

(Note: All Pages shown in Yellow should be printed on YELLOW PAPER)
(Note: All Pages shown in Blue should be printed on BLUE PAPER)

Course Description in ABET Format

CHEG 4304: CHEMICAL PROCESS DESIGN AND ANALYSIS

- | | |
|---|--|
| 1. Course number and name: | CHEG 4304: Chemical Process Design and Analysis |
| 2. Credits, contact hours, categorization: | 3-Credit Hour, 3-Contact Hours, Engineering Topic |
| 3. Instructor's or course coordinator's name: | Dr. Emmanuel A. Dada |
| 4. Text book: Title: | "Analysis, Synthesis, and Design of Chemical Processes" |
| Authors: | Turton, R., Bailie, R., Whiting, W., and Shaeiwits, J. A. |
| Publisher, Year & Edition: | Prentice –Hall PTR Upper Saddle River, New Jersey, 2008, 4th Edition |
| a.Other Supplemental material | <ol style="list-style-type: none">1.Chemical Engineering Design By Galvin Towler and Ray Snnott2.Product & Process Design Principles By Seider, Sader and Lewin.3.Plant Design and Economics for Chemical Engineers by Max Peters, et al Fifth Edition.4.Chemical Process Engineering Design and Economics by Harry Slla5.Systematic Methods of Chemical Process Design by Biegler, Grossman, and Westerberg |
| 5. Specific course information | |
| a.Brief description of the content of the course (catalog description) | CHEG 4304 (3:0) Credit 3 semester hours. Use of material and energy balances calculations, thermodynamics, transfer operations, reaction kinetics and process economics for the synthesis and analysis of chemical processing systems. Design alternatives are analyzed by the use of case studies, computerized flowsheet modeling and simulation, and optimization methods. Safety and design codes are emphasized. |
| b. Prerequisites | CHEG 3301, 3302, 3305, & 3306 |
| c.*Indicate whether a required, elective, or selected elective (as per definition provided) course in the program | Required |
| 6. Specific goals for the course | Students will be able to : |
| a.specific outcomes of instruction | <ol style="list-style-type: none">1. Allow senior chemical engineering students to perform design of chemical processes using the knowledge learnt throughout the chemical curriculum.2. Design modifications to existing processes and hardware.3. To participate in the AIChE design competition.4. To develop an innovative teaching experience involving self-study and group work.5. An ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts |
| b. Explicitly indicate which of the student outcomes listed in Criterion 3 or any other outcomes are addressed by the course. | This course addresses the following student learning outcome determined by the department:

Outcome 4 |

An ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts

7 Brief list of topics to be covered

1. Process flow diagram (PFD), process topology, symbols, conventions, numbering of equipment. Introduction to VISIO,
2. Structure & synthesis of PFDs. Batch versus continuous processes. Input-output structure of the process.
3. Recycle structure of the process. Efficiency of raw material usage. Basic recycle structures.
4. Engineering economic analysis of chemical processes.
5. Factors affecting cost of manufacturing. Labor cost.
6. Engineering economic analysis. Profitability analysis.
7. Typical CFD for evaluation of a new project.
Profitability criteria for project evaluation. Evaluation of equipment alternatives. Profit margin.
8. Utilizing experienced-based principles to confirm the suitability of a process design. Role of experience.
9. Analysis of process performance. Multiple unit operations. Reactor performance. Regulating process conditions.
10. Ethics & professionalism

Additional Course Syllabus Information

Course Requirements & Evaluation Methods

This course will utilize the following instruments to determine student grades and proficiency of the learning outcomes for the course. The course has been designed to ensure that students acquire a solid grounding in ABET outcome 4.

Outcome 4: An ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts

Computer Assignments – self-explanatory assignments. .

Homework Exercises – written assignments, often in letter report format, designed to supplement and reinforce course material. The letter report format serves to develop and demonstrate an ability to communicate effectively in written mode.

Quizzes – announced or surprise in-class assignments to promote student accountability **Partial Tests** – the objective is determining concept development and problem-solving skills. . **Final Examination** – Comprehensive final exam.

Grading Matrix *(points will vary according to instructor's grading system)*

Instrument	Total
Homework, Computer Assignments & Quizzes	30%
Partial Exams.	40%
Final Exam	30%
Total	100%

Grade Determination:

A= 90 – 100 pts;

B= 80 – 89 pts;

C= 70 – 79 pts;

D= 60 – 69pts;

F = 00 – 60 pts

Course Procedures

Textbook Policy Students must acquire the textbook that is listed as “required” on the course syllabus. The textbook must be acquired by the 10th class day. Students are not allowed to share textbooks with other students who are currently registered in the same class. Failure to acquire (or show proof of purchase) the required textbook by the 10th class day will result in the student being administratively dropped from the course. The University will assess financial obligations for the course to the student as with any other dropped class according to the fee schedule. In addition, your financial aid may be affected by the subsequent registration action(s).

Go to <http://www.pvamu.edu/pages/195.asp> for the Roy G. Perry College of Engineering Textbook Policy.

Conduct:

1. Students will conduct themselves in a manner that is respectful to their fellow classmates and the instructor at all times.
2. **Cell phones MUST** be turned off during class time. Students are **NOT** allowed to leave class to answer cell phones.
3. Students are **NOT** allowed to wear caps/hats in class
4. Arrive to class prepared to discuss lesson.
5. Always bring essential tools: Textbook, paper, calculator.

Submission of Assignments:

□ All assignments are due by default one week after being given, unless otherwise stated.

All homework assignments are due directly to the Instructor, prior to the start of class or the assignment will not be accepted. All homework assignments and exams should be written on one side of the page only, and should use the appropriate cover sheet, with the name, assignment title and date. All pages should be numbered. Failure to use the correct format will result in the assignment grade being reduced by 20%.

Exam Policy

Exams should be taken as scheduled. No makeup examinations will be allowed except under documented emergencies (See Student Handbook).

TOPICS

Topic 1	Introduction (3 classes)
Topic 2	Process Flow Diagrams (5 classes)
Topic 3	Material and Energy Balances (9 classes)
Topic 4	Economics (6 classes)
Topic 5	Economic evaluation of projects (8 classes)
	Tests. (4 classes)

Student Support and Success

John B. Coleman Library

The John B. Coleman Library's mission is to enhance the scholarly pursuit of knowledge, to foster intellectual curiosity,

and to promote life-long learning and research through our innovative services, resources, and cultural programs, which support the Prairie View A&M University's global mission of teaching, service, and research. It maintains library collections and access both on campus, online, and through local agreements to further the educational goals of students and faculty. Website: <https://www.pvamu.edu/library/>; Phone: 936-261-1500

Academic Advising Services

Academic Advising Services offers students a variety of services that contributes to student success and leads towards graduation. We assist students with understanding university policies and procedures that affect academic progress. We support the early alert program to help students get connected to success early in the semester. We help refer students to the appropriate academic support services when they are unsure of the best resource for their needs. Faculty advisors support some students in their respective colleges. Your faculty advisor can be identified in PantherTracks. Advisors with Academic Advising Services are available to all students. We are located across campus. Find your advisor's location by academic major at www.pvamu.edu/advising. Phone: 936-261-5911

The University Tutoring Center

The University Tutoring Center (UTC) offers free tutoring and academic support to all registered PVAMU students. The mission of the UTC is to help provide a solid academic foundation that enables students to become confident, capable, independent learners. Competent and caring staff and peer tutors guide students in identifying, acquiring, and enhancing the knowledge, skills, and attitudes needed to reach their desired goals. Tutoring and academic support are offered face-to-face in the UTC, in virtual face-to-face sessions (<https://www.pvamu.edu/student-success/sass/university-tutoring-center/>), and through online sessions (<https://www.pvamu.edu/pvplace/>). Other support services available for students include Supplemental Instruction, Study Break, Academic Success Workshops, and Algebra Study Jam. Location: J. B. Coleman Library, Rm. 307; Phone: 936-261-1561; Email: pvtutoring@pvamu.edu; Website: <https://www.pvamu.edu/student-success/sass/university-tutoring-center/>

Writing Center

The Writing Center provides well-trained peer tutors to assist students with writing assignments at any stage of the writing process. Tutors help students with various writing tasks from understanding assignments, brainstorming, drafting, revising, editing, researching, and integrating sources. Students have free access to Grammarly online writing assistance. Grammarly is an automated proofreading and plagiarism detection tool. Students must register for Grammarly by using their student email address. In addition, students have access to face-to-face and virtual tutoring services either asynchronously via email or synchronously via Zoom. Location: J. B. Coleman Library, Rm. 209; Phone: 936-261-3724; Website: <https://www.pvamu.edu/student-success/writing-center/>; Grammarly Registration: <https://www.grammarly.com/enterprise/signup>

Academic Early Alert

Academic Early Alert is a proactive system of communication and collaboration between faculty, academic advisors, and PVAMU students that is designed to support student success by promptly identifying issues and allowing for intervention. Academic Early Alerts help students by providing a central location to schedule advising appointments, view advisor contact information, and request assistance. Students who recognize that they have a problem that is negatively affecting their academic performance or ability to continue school may self-refer an Academic Early Alert. To do so, students will log in to PV Place and click on Academic Early Alert on the left sidebar. Phone: 936-261-5902; Website: <https://www.pvamu.edu/student-success/early-alert/>

Student Counseling Services

The Student Counseling Services unit offers a range of services and programs to assist students in maximizing their potential for success: short-term individual, couples, and group counseling, as well as crisis intervention, outreach, consultation, and referral services. The staff is licensed by the State of Texas and assists students who are dealing with academic skills concerns, situational crises, adjustment problems, and emotional difficulties. Information shared with the staff is treated confidentially and in accordance with Texas State Law. Location: Hobart Taylor, 2nd floor; Phone: 936-261-3564; Website: <https://www.pvamu.edu/healthservices/student-counseling-services/>

Office of Testing Services

Testing Services serves to create opportunities by offering a suite of exams that aid in the students' academic and professional success. Currently, we administer entrance (HESI A2), college readiness (TSI assessment), Prior Learning (CLEP, DSST), and proctored exams. Location: Wilhelmina Delco, 3rd Floor, Rm. 305; Phone: 936-261-3627; Email: aetesting@pvamu.edu; Website: www.pvamu.edu/testing

Office of Diagnostic Testing and Disability Services

The Americans with Disabilities Act (ADA) is a federal anti-discrimination statute that provides comprehensive civil rights protection for persons with disabilities. Among other things, this legislation requires that all students with disabilities be guaranteed a learning environment that provides for reasonable accommodation of their disabilities. If you believe you have a disability requiring an accommodation, contact the Office of Disability Services. As a federally-mandated educational support unit, the Office of Disability Services serves as the repository for confidential disability files for faculty, staff, and students. For persons with a disability, the Office develops individualized ADA letters of request for accommodations. Other services include learning style inventories, awareness workshops, accessibility pathways, webinars, computer laboratory with adapted hard and software, adapted furniture, proctoring non-standardized test administrations, ASL interpreters, ALDs, digital recorders, Livescribe, and a comprehensive referral network across campus and the broader community. Location: Hobart Taylor, Rm. 1D128; Phone: 936-261-3583; Website: <https://www.pvamu.edu/disabilityservices/>

Center for Instructional Innovation and Technology Services (CIITS)

Distance Learning, also referred to as Distance Education, is the employment of alternative instructional delivery methods to extend programs and services to persons unable to attend college in the traditional manner. The Center for Instructional Innovation and Technology Services (CIITS) supports student learning through online, hybrid, web-assist, and 2-way video course delivery. For more details and contact information, visit: <https://www.pvamu.edu/dlearning/distance-learning-2-2/students-2/>; Phone: 936-261-3283

Veteran Affairs

Veterans Services works with student veterans, current military and military dependents to support their transition to the college environment and continued persistence to graduation. The Office coordinates and certifies benefits for both the G.I. Bill and the Texas Hazlewood Act. Location: Evans Hall, Rm. 102; Phone: 936-261-3563; Website: <https://www.pvamu.edu/sa/departments/veteranaffairs/>

Office for Student Engagement

The Office for Student Engagement delivers comprehensive programs and services designed to meet the co-curricular needs of students. The Office implements inclusive and accessible programs and services that enhance student development through exposure to and participation in diverse and relevant social, cultural, intellectual, recreational, community service, leadership development, and campus governance. Location: Memorial Student Center, Rm. 221; Phone: 936-261-1340; Website: <https://www.pvamu.edu/studentengagement/>

Career Services

Career Services supports students through professional development, career readiness, and placement and employment assistance. The Office provides one-on-one career coaching, interview preparation, resume and letter writing, and career exploration workshops and seminars. Services are provided for students at the Northwest Houston Center and College of Nursing in the Medical Center twice a month or on a requested basis. Distance Learning students are encouraged to visit the Career Services website for information regarding services provided. Location: Anderson Hall, 2nd floor; Phone: 936-261-3570; Website: <https://www.pvamu.edu/careerservices/>

University Rules and Procedures

Academic Misconduct

Academic dishonesty is defined as any form of cheating or dishonesty that has the effect or intent of interfering with any academic exercise or fair evaluation of a student's performance. The college faculty can provide additional information, particularly related to a specific course, laboratory, or assignment.

You are expected to practice academic honesty in every aspect of this course and all other courses. Make sure you are familiar with the *University Administrative Guidelines on Academic Integrity*, which can be found on the [Academic Integrity webpage](#). Students who engage in academic misconduct are subject to university disciplinary procedures. As listed in the *University Administrative Guidelines on Academic Integrity*, the University Online Catalog, and the Student Code of Conduct, the following are examples of prohibited conduct. This list is not designed to be all-inclusive or exhaustive. In addition to academic sanctions, any student found to have committed academic misconduct that is also a violation of criminal law may also be subject to disciplinary review and action by the Office of Student Conduct (as outlined in the Student Code of Conduct).

Forms of Academic Dishonesty:

1. **Cheating**: Deception in which a student misrepresents that he/she has mastered information on an academic exercise that he/she has not learned, giving or receiving aid unauthorized by the instructor on assignments or examinations. Examples: unauthorized use of notes for a test; using a "cheat sheet" on a quiz or exam; any alteration made on a graded test or exam which is then resubmitted to the teacher;
2. **Plagiarism**: Careless or deliberate use of the work or the ideas of another; representation of another's work, words, ideas, or data as your own without permission or appropriate acknowledgment. Examples: copying another's paper or answers, failure to identify information or essays from the internet and submitting or representing it as your own; submitting an assignment which has been partially or wholly done by another and claiming it as yours; not properly acknowledging a source which has been summarized or paraphrased in your work; failure to acknowledge the use of another's words with quotation marks;
3. **Collusion**: When more than one student or person contributes to a piece of work that is submitted as the work of an individual;
4. **Conspiracy**: Agreeing with one or more persons to commit an act of academic/scholastic dishonesty; and
5. **Multiple Submission**: Submission of work from one course to satisfy a requirement in another course without explicit permission. Example: using a paper prepared and graded for credit in one course to fulfill a requirement and receive credit in a different course.

Nonacademic Misconduct

The university respects the rights of instructors to teach and students to learn. Maintenance of these rights requires campus conditions that do not impede their exercise. Campus behavior that interferes with either (1) the instructor's ability to conduct the class, (2) the inability of other students to profit from the instructional program, or (3) campus behavior that interferes with the rights of others will not be tolerated. An individual engaging in such disruptive behavior may be subject to disciplinary action. The Office of Student Conduct will adjudicate such incidents under nonacademic procedures.

Sexual Misconduct

Sexual harassment of students and employees at Prairie View A&M University is unacceptable and will not be tolerated. Any member of the university community violating the university's sexual harassment policy will be subject to disciplinary action. In accordance with the Texas A&M University System guidelines, your instructor is obligated to report to the Office of Title IX Compliance (titleixteam@pvamu.edu) any instance of sexual misconduct involving a student, which includes sexual assault, stalking, dating violence, domestic violence, and sexual harassment, about which the instructor becomes aware during this course through writing, discussion, or personal disclosure. The faculty and staff of PVAMU actively strive to provide a learning, working, and living environment that promotes respect that is free from sexual misconduct, discrimination, and all forms of violence. If students, faculty, or staff would like assistance or have questions, they may contact the Title IX Coordinator at 936-261-2144 or titleixteam@pvamu.edu. More information can be found at www.pvamu.edu/titleix, including confidential resources available on campus.

Pregnancy, Pregnancy-related, and Parenting Accommodations

Title IX of the Education Amendments of 1972 prohibits sex discrimination, which includes discrimination based on pregnancy, marital status, or parental status. Students seeking accommodations related to pregnancy, pregnancy-related conditions, or parenting (reasonably immediate postpartum period) are encouraged to contact Student Disability Services or the Dean of Students' Office for additional information and to request accommodations.

Non-Discrimination Statement

Prairie View A&M University does not discriminate on the basis of race, color, sex, religion, national origin, age, disability, genetic information, veteran status, sexual orientation, or gender identity in its programs and activities. The University is committed to supporting students and complying with The Texas A&M University System non-discrimination policy. It seeks to establish an environment that is free of bias, discrimination, and harassment. If you experience an incident of discrimination or harassment, we encourage you to report it. If you would like to speak with someone who may be able to afford you privacy or confidentiality, there are individuals who can meet with you. The Director of Equal Opportunity & Diversity has been designated to handle inquiries regarding the non-discrimination policies and can be reached at Harrington Science Building, Suite 109 or by phone at 936-261-1744 or 1792.

Class Attendance Policy (See the University Online Catalog for Full Attendance Policy)

Prairie View A&M University requires regular class attendance. Attending all classes supports the full academic development of each learner, whether classes are taught with the instructor physically present or via distance learning technologies such as interactive video and/or the internet. Excessive absenteeism, whether excused or

unexcused, may result in a student's course grade being reduced or in the assignment of a grade of "F." Absences are accumulated beginning with the first day of class during regular semesters and summer terms. Each faculty member will include the University's attendance policy in each course syllabus.

Student Academic Appeals Process

Authority and responsibility for assigning grades to students rest with the faculty. However, in those instances where students believe that miscommunication, errors, or unfairness of any kind may have adversely affected the instructor's assessment of their academic performance, the student has a right to appeal by the procedure listed in the University Online Catalog and by doing so within thirty days of receiving the grade or experiencing any other problematic academic event that prompted the complaint.

Technical Considerations

Minimum Recommended Hardware and Software:

- Intel PC or Laptop with Windows 10 or later version; Mac with OS High Sierra*
- Smartphone or iPad/Tablet with Wi-Fi*
- High-speed Internet access
- 8 GB Memory
- Hard drive with 320 GB storage space
- 15" monitor, 800x600, color or 16 bit
- Sound card w/speakers
- Microphone and recording software
- Keyboard & mouse
- Most current version of Google Chrome, Safari, or Firefox

Note: Be sure to enable Java & pop-ups in the Web browser preferences

* Smartphones, Google Chrome books, and Android tablets may not be supported. iPads are the only tablets supported.

Participants should have a basic proficiency of the following computer skills:

- Sending and receiving email
- A working knowledge of the Internet
- Microsoft Word (or a program convertible to Word)
- Acrobat PDF Reader
- Windows or Mac OS
- Video conferencing software

Netiquette (online etiquette)

Students are expected to participate in all discussions and virtual classroom chats as directed. Students are to be respectful and courteous to others on discussion boards. Foul or abusive language will not be tolerated. Do not use ALL CAPS for communicating to others AS IT CAN BE INTERPRETED AS YELLING. Avoid slang terms such as "wassup?" and texting abbreviations such as "u" instead of "you." Limit and possibly avoid the use of emoticons. Be cautious when using humor or sarcasm as tone is sometimes lost in an email or discussion post, and the message might be taken seriously or sound offensive.

Video Conferencing Etiquette

When using Zoom, WebEx, or other video conferencing tools, confirm the visible area is tidy, clear of background clutter, inappropriate or offensive posters, and other distractions. Ensure you dress appropriately and avoid using high traffic or noisy areas. Stay muted when you are not speaking and avoid eating/drinking during the session. Before the class session begins, test audio, video, and lighting to alleviate technology issues.

Technical Support

Students should go to <https://mypassword.pvamu.edu/> if they have password issues. The page will provide instructions for resetting passwords and contact information if login issues persist. For other technical questions regarding eCourses, call the Center for Instructional Innovation and Technology Services at 936-261-3283 or email ciits@pvamu.edu.

Communication Expectations and Standards

Emails or discussion postings will receive a response from the instructor, usually in less than 48 hours. Urgent emails should be marked as such. Check regularly for responses.

Discussion Requirement

Online courses often require minimal to no face-to-face meetings. However, conversations about the readings, lectures, materials, and other aspects of the course can occur in a seminar fashion. The use of the discussion board will accomplish this. The instructor will determine the exact use of discussion boards.

It is strongly suggested that students type their discussion postings in a word processing application such as Word and save it to their PC or a removable drive before posting to the discussion board. This is important for two reasons: 1) If for some reason your discussion responses are lost in your online course, you will have another copy; 2) Grammatical errors can be greatly minimized by the use of the spell-and-grammar check functions in word processing applications. Once the post(s) have been typed and corrected in the word processing application, copy and paste to the discussion board.

COVID-19 Campus Safety Measures [NOTE: Delete this section when the COVID-19 pandemic is over]

To promote public safety and protect students, faculty, and staff during the coronavirus pandemic, PVAMU has adopted policies and practices to limit virus transmission.

- **Self-monitoring** - Students should follow CDC recommendations for self-monitoring. Students who have a fever or exhibit symptoms of COVID-19 should participate in class remotely and should not participate in face-to-face instruction.
- **Face Coverings** - Face coverings (cloth face covering, surgical mask, etc.) are recommended in classrooms, teaching laboratories, common spaces such as lobbies and hallways, public study spaces, libraries, academic resource, and support offices, and outdoor spaces where 6 feet of physical distancing is challenging to maintain reliably.
- **Physical Distancing** - Physical distancing should be maintained between students, instructors, and others in course and course-related activities where possible.
- **Personal Illness and Quarantine** - Students required to quarantine are to participate in courses and course-related activities remotely and must not attend face-to-face course activities. Students should notify their instructors of the quarantine requirement. Students under quarantine are expected to participate in courses and complete graded work unless they have symptoms that are too severe to participate in course activities. Students experiencing personal injury or illness that is too severe for the student to attend class qualify for an excused absence. To receive an excused absence, students must provide appropriate documentation to the Office for Student Conduct, studentconduct@pvamu.edu.

II ASSESSMENT RESULTS FOR CURRENT AND PAST THREE PERIODS

Program Outcomes Assessed in this course

Outcome 4:

An ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts

Assessment Summary of Class Semester Averages for Outcomes
(Should be provided for Spring 2021 through Spring 2022 Assessment Period)

Outcomes	4
Semester	Semester Class Average (%)
FALL 2021	82
FALL 2020	70
FAL 2019	79
Comments on Trend of Data (Improving or deteriorating)	The COVID-19 pandemic greatly affected the performance of our students in 2020 compare with preceding year 2019. However with COVID-19 impact reducing, our students performed better in 2021 compare with 2020.

*Expected Semester Class Average = 70% (or as defined by the program)
Ideal Semester Class Average =75% (or as defined by the program)

End of Semester Course Assessment Reports Fall 2021 and Last Three Assessment Periods.

Each summary contains the following Information

1. Performance Statistics

- Total number of students in class
- The class average performance (**stated as %**) in each course outcome assessed in this class and the **two previous times course was assessed**.
- The acceptable class average for the class in each outcome area as set by your Department.
- Percentage of students who scored below the expected average in each outcome.

2. Implementation Summary

- Brief summary of plans implemented during the semester based on last assessment report

3. Perceived Problems

- Instructor's **critical evaluation** of perceived problems that affected students' performance. **Realistic problems should be identified throughout the semester and summarized in this section of the report.**

4. New Plans for Addressing Problems

- Instructor's plans for addressing the perceived problems the next time the class is taught. **These should be specific enough for another instructor to implement. Most of these should be things that, you, the instructor can implement to help students to improve. Be creative.**

5. Overall Trend over last three assessment periods

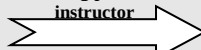
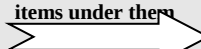
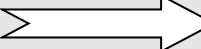
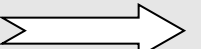
- Instructors summary of overall performance trend for each outcome measured over the last three periods.

5. Were Expectations Met?

- Answer **YES** if the **class average was above the expected average** and the **stated percentage of students** scored at or above the expected average, else answer **NO**.

END OF SEMESTER COURSE OUTCOME ASSESSMENT REPORT
CHEG 4304- PO2 PROCESS DESIGN AND ANALYSIS
FALL 2021 SEMESTER

Report Prepared by: Dr. Emmanuel Dada Report Date: December 26, 2021

Semester	Analysis Type	Number of Students	Outcome 4 An ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts			
			Expected Class Average	Expected Percent of students at or above average	Class Average	% Students meeting Expected Average
Fall 2021	Direct	26	75	70	82	58
Fall 2020	Direct	17	75	70	70	35
Fall 2019	Direct	27	75	70	79	78
Implementation Summary	Items implemented from previous report or after meeting previous instructor 	The importance of recognizing ethical and professional responsibilities in engineering situations with consideration of impact of engineering solutions global, economic, environmental, and societal contexts.				
Perceived Problems	Perceived problems are directly related to the PC and the sub items under them 	A few students have difficulties in recognizing the difference between ethical and legal implications of engineering situations.				
Plans for Addressing Problems	Plans for address specific measures to address PC and their sub areas 	The instructor should continue to stress that there are situations that may be moral but not legal.				
Overall Trend over Periods	Ascertain if there were improvements over previous semesters 	The COVID-19 pandemic greatly affected the performance of our students in 2020 compare with the preceding year 2019. However with COVID-19 impact reducing, our students performed better in 2021 compare with 2020.				
Were Expectations Met?	Class Average ≥75% and ≥63 % of Students Performed at or Above Expected Average. 	YES				

**CHEMICAL ENGINEERING PROCESS DESIGN AND ANALYSIS
FALL 2021**

Title of Assignment: Final Exam

NOTE: WORK MUST BE INDEPENDENT (INDIVIDUAL).

Problem 1: You are the process engineer in a plant that needs to select equipment for one of their units operations. The after-tax hurdle rate is 12% per annum. From the below three alternative choices which one would you recommend?

Alternative	Equipment Life (Yr)	Capital Cost (\$Million)	Operating Cost (\$Million)
A	9	24	2.6
B	5	16	3.6
C	3	6	5.6

Hint: Use Equivalent Annual Operating Cost (EAOC) method

Problem 2: As a chemical engineer with Bestdeal Company, Houston, TX you were part of the team that carried out a good estimate for all the major equipment for the production of a plant for the new product to be on stream in 2021. The cost of the major equipment carried out in the year 2006 are: Reactors-\$400K; Distillation Units - \$600K; Separators- \$250K, others - \$150K. Assume that the current chemical engineering cost index (CECI) in 2021 is 610:

- (1) Calculate the current fixed capital cost for the plant using the estimating cost software in “Plant Design and Economics for Chemical Engineers”, 5th edition, by Peters, Timmerhaus and West. Show the details of your estimate by providing both the indirect and direct costs. (Hint: From your class text book, locate the CECI for the year 2006.)
- (2) Calculate the total capital investment in 2021 if the working capital is 20% of the fixed capital investment.
- (3) The plant has 10 years life and at the end of its life 15% of the original fixed capital investment is recovered as salvage value and 10% of the working capital is also recovered. Calculate (a) the NPV and (b) the payback period of the plant assume that the after-tax hurdle rate is 10% and the annual cash flow is \$1 million per year.
- (4) From question 3 above, calculate the discounted cash flow rate of return on investment for the plant.
- (5) If the plant is to be replicated in Denmark but with production capacity tripled due to a large demand, calculate the new fixed capital cost of the plant in euro (assume 1Euro = \$1.30). Note that each item of the major equipment is 50% relatively more expensive in Denmark compare to US; that is for example in 2006, a reactor that cost \$1.00 in US cost a euro equivalent of \$1.50 in Denmark. And also one major 100 gpm pump equipment is to be added necessary to meet Denmark’s market. The information on this particular equipment in 2006 are: Twice its capacity cost \$100K and triple its capacity cost \$125K. (Hint: Calculate the capacity exponent value that will help you to calculate the cost of the additional major equipment to meet Denmark’s market. Then you update the cost of all the major equipment.)

ABOVE AVERAGE

(Note: All Pages shown in Light Blue should be printed on Light Blue Paper)

Above Average Student Original Graded Assignment on Final Exam

Final Exam Due Tuesday, December 7, 2021. Instructor: Dr. Emmanuel Dada

Name of Student: OLUNATAYOSI IDANU

NOTE: WORK MUST BE INDEPENDENT (INDIVIDUAL).

Problem 1: You are the process engineer in a plant that needs to select equipment for one of their units operations. The after-tax hurdle rate is 12% per annum. From the below three alternative choices which one would you recommend?

Alternative	Equipment Life (Yr)	Capital Cost (\$Million)	Operating Cost (\$Million)
A	9	24	2.6
B	5	16	3.6
C	3	6	5.6

Hint: Use Equivalent Annual Operating Cost (EAOC) method

Problem 2: As a chemical engineer with Bestdeal Company, Houston, TX you were part of the team that carried out a good estimate for all the major equipment for the production of a plant for the new product to be on stream in 2021. The cost of the major equipment carried out in the year 2006 are: Reactors- \$400K; Distillation Units - \$600K; Separators- \$250K, others - \$150K. Assume that the current chemical engineering cost index (CECI) in 2021 is 610:

- (1) Calculate the current fixed capital cost for the plant using the estimating cost software in "Plant Design and Economics for Chemical Engineers", 5th edition, by Peters, Timmerhaus and West. Show the details of your estimate by providing both the indirect and direct costs. (Hint: From your class text book, locate the CECI for the year 2006.)
- (2) Calculate the total capital investment in 2021 if the working capital is 20% of the fixed capital investment.
- (3) The plant has 10 years life and at the end of its life 15% of the original fixed capital investment is recovered as salvage value and 10% of the working capital is also recovered. Calculate (a) the NPV and (b) the payback period of the plant assume that the after-tax hurdle rate is 10% and the annual cash flow is \$1 million per year.
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- (5) If the plant is to be replicated in Denmark but with production capacity tripled due to a large demand, calculate the new fixed capital cost of the plant in euro (assume 1Euro = \$1.30). Note that each item of the major equipment is 50% relatively more expensive in Denmark compare to US; that is for example in 2006, a reactor that cost \$1.00 in US cost a euro equivalent of \$1.50 in Denmark. And also one major 100 gpm pump equipment is to be added necessary to meet Denmark's market. The information on this particular equipment in 2006 are: Twice its capacity cost \$100K and triple its capacity cost \$125K. (Hint: Calculate the capacity exponent value that will help you to calculate the cost of the additional major equipment to meet Denmark's market. Then you update the cost of all the major equipment.)

29/30

P1) EADC WILL BE POSITIVE BECAUSE YOU ARE DEALING WITH COST. THE BEST ALTERNATIVE WILL BE THE ONE WITH THE SMALLEST EADC

$$EADC = (\text{CAPITAL INVESTMENT})(A/P, i, n) + \text{YEARLY OPERATING COST}$$

$$(A/P, i, n) = \frac{i(1+i)^n}{(1+i)^n - 1}$$

$$\text{ALTERNATIVE A} = 24,000,000 \frac{0.12(1.12)^9}{1.12^9 - 1} + 2,600,000 = 7,104,293$$

$$\text{ALTERNATIVE B} = 16,000,000 \frac{0.12(1.12)^5}{1.12^5 - 1} + 3,600,000 = 8,038,556$$

$$\text{ALTERNATIVE C} = 6,000,000 \frac{0.12(1.12)^3}{1.12^3 - 1} + 5,600,000 = 8,098,094$$

I WOULD RECOMMEND ALTERNATIVE A

10/10

P2.) CALCULATE THE CURRENT FIXED CAPITAL COST FOR THE PLANT
 (1) MAJOR EQUIPMENT COST IN 2006 = \$400K, \$600K, \$250K, \$150K = \$1.4 million

USING EQUATION OF TIME TO FIND COST IN 2021

$$C_2 = C_1 \left(\frac{I_2}{I_1} \right)^{\frac{2021 \text{ INDEX}}{2006 \text{ INDEX}}}$$

2021 COST 2006 COST

$$1.4 \left(\frac{610}{500} \right) = \$1,708m \approx \$1.710m$$

EQUIPMENT COST IN 2021

2021 COST INDEX = 610

2006 COST INDEX = 500

COST OF MAIN EQUIPMENT IN 2021

$$\text{REACTOR} : 400 \left(\frac{610}{500} \right) = \$488K$$

$$\text{DISTILLATION} : 600 \left(\frac{610}{500} \right) = \$732K$$

$$\text{SEPARATOR} : 250 \left(\frac{610}{500} \right) = \$305K$$

$$\text{OTHER} : 150 \left(\frac{610}{500} \right) = \$183K$$

* DIRECT COST

- ACCORDING TO PETER AND TIMMERHAUS SOFTWARE

• DELIVERY : 10% OF PURCHASED EQUIPMENT = $\$1.710m \times 0.10 = \$0.171m$

• SUBTOTAL OF DELIVERED EQUIPMENT = $\$1.710m + \$0.171m = \$1.881m$

• EQUIPMENT INSTALLATION 0.47 = $\$0.884m$

• INSTRUMENTATION AND CONTROL 0.36 = $\$0.677m$

• PIPING 0.68 = $\$1.279m$

• ELECTRICAL SYSTEM 0.11 = $\$0.207m$

• BUILDINGS 0.18 = $\$0.339m$

• YARD IMPROVEMENT 0.10 = $\$0.1881m$

• SERVICE FACILITIES 0.70 = $\$1.317m$

TOTAL DIRECT COST = $\$6.772m$

* INDIRECT COST

• ENGINEERING AND SUPERVISION 0.33 = $\$0.621m$

• CONSTRUCTION EXPENSES 0.41 = $\$0.771m$

• LEGAL EXPENSES 0.04 = $\$0.075m$

• CONTRACTOR'S FEE 0.22 = $\$0.414m$

• CONTINGENCY 0.44 = $\$0.828m$

TOTAL INDIRECT COST = $\$2.709m$

• CURRENT FIXED COST = $\$6.772m + \$2.709m = \$9.481m$

(2) CALCULATE TOTAL CAPITAL INVESTMENT IN 2021 IF WORKING CAPITAL IS 20% OF FIXED CAPITAL INVESTMENT.

$$\text{TOTAL CAPITAL INVESTMENT} = \text{FIXED CAPITAL} + \text{WORKING CAPITAL}$$

$$\text{FIXED CAPITAL} = \$9.481\text{m}$$

$$\text{WORKING CAPITAL} = \$9.481 \times 0.20 = \$1.896\text{m}$$

$$\text{TCI} = \$9.481\text{m} + \$1.896\text{m} = \boxed{\$11.377\text{m}}$$



(3) CALCULATE THE NPV AND THE PAYBACK PERIOD OF THE PLANT ASSUME THAT THE AFTER-TAX HURDLE RATE IS 10% AND THE ANNUAL CASH FLOW IS \$1 million PER YEAR

$$\text{CASH FLOW (A)} = \$1\text{million}$$

$$\text{PLANT LIFE (n)} = 10 \text{ YEARS}$$

$$\text{SAVAGE} = 0.15 \times \$9.481\text{m} = \$1.422\text{m}$$

$$\text{WORKING CAPITAL (RECOVERED)} = 0.10 \times \$1.896 = \$0.190\text{m}$$

$$\text{NPV} = -\text{FCI} - \text{INC} \times (P/F, 0.1, 1) + A (P/A, 0.1, 10) (P/F, 0.1, 1) + (S + \text{WCR}) (P/F, 0.1, 10)$$

$$\left(\frac{1}{1+i}\right), \left(\frac{(1+i)^n - 1}{i(1+i)^n}\right), \quad \downarrow \quad \downarrow \quad \downarrow \quad \downarrow$$

$$\left(\frac{1}{(1+i)^0}\right), \quad \frac{1}{1.1} = 0.91, \quad \frac{(1.1)^{10} - 1}{0.1(1.1)^{10}} = 6.14, \quad 0.91, \quad \frac{1}{(1.1)^{10}} = 0.385$$

$$= -9.481 - 1.896 \times (0.91) + 1(6.14)(0.91) + (1.422 + 0.190)(0.385) = \boxed{-\$5.1\text{m}}$$

(5) PAYBACK PERIOD = $\frac{\text{TCI}}{A} = \frac{\$11.377\text{m}}{\$1\text{m}} = 11.377 \text{ YEARS}$ is 11.377 years? ✓

PBP IS GREATER THAN THE PLANT LIFE SO NO PROFIT IS MADE

(4) CALCULATE THE DISCOUNTED CASH FLOW RATE OF RETURN ON INVESTMENT FOR THE PLANT:

DCFRR = INTEREST OR DISCOUNT RATE FOR WHICH THE NPV OF THE PROJECT IS EQUAL TO ZERO

— USING GOAL SEEK, THE DISCOUNT RATE WOULD HAVE TO BE

$$0.0030 \approx 0.30\% \text{ FOR NPV TO BE ZERO}$$

OK

$$5.) C_a = K A_a^n \quad C_b = K A_b^n \quad \frac{C_a}{C_b} = \left(\frac{A_a}{A_b} \right)^n$$

$$\frac{C_a}{C_b} = \left(\frac{A_a}{A_b} \right)^n = \frac{100k}{125k} \left(\frac{200gpm}{300gpm} \right)^n \quad n = 0.55$$

$$K = \frac{C_b}{A_b^n} = \frac{125k}{300^{0.55}} = 5.426$$

$$\text{COST OF 100gpm PUMP} = 5.426 (100)^{0.55} = \$68.31k - \text{US PRICE}$$

* GIVEN COST OF EQUIPMENT IN US IN 2006:

$$\text{REACTOR} = \$400k$$

$$\text{DISTILLATION} = \$600k$$

$$\text{SEPARATOR} = \$250k$$

$$\text{OTHERS} = \$150k$$

$$\text{TOTAL} = \$1.4m$$

* COST OF EQUIPMENT IN DENMARK IN 2006 : 50% HIGHER THAN US IN 2006

$$\text{REACTOR} = \$600k$$

$$\text{DISTILLATION} = \$900k$$

$$\text{SEPARATOR} = \$375k$$

$$\text{OTHERS} = \$225k$$

$$\text{TOTAL} = \$2.1m$$

* PRICE OF 100gpm PUMP IN DENMARK IN 2006 : 50% HIGHER THAN US IN 2006

$$\text{US PRICE FOR PUMP} = \$68.31k$$

$$\text{DENMARK PRICE FOR PUMP} = \$102.47k$$

* NOW TRIPLE THE CAPACITY OF PLANT IN DENMARK WITHOUT THE PUMP

$$C_a = C_b \left(\frac{A_a}{A_b} \right)^n$$

$$= \$2.1m \left(\frac{3}{1} \right)^{0.6}$$

$$= \$4.06m \text{ in DENMARK}$$

* $n = 0.6$ DUE TO THE FACT THAT THIS IS THE COMMON PLANT CAPACITY EXPONENTIAL VALUE

TRIPLE CAPACITY + PUMP PRICE IN DENMARK IN 2006 = PLANT PRICE IN 2006

$$\$4.06m + \$102.47k = \$4,162,470$$

PLANT PRICE IN 2021 IN DENMARK

$$C_2 = C_1 \left(\frac{I_2}{I_1} \right)$$

$$= \$4,162,470 \left(\frac{610}{500} \right) = \$5,078,213 \text{ in DENMARK}$$

* CONVERT TO EURO

$$\frac{€1}{\$1.30} = \frac{\$5,078,213}{x}$$

$$= €3,906,318$$

* DIRECT COST IN EURO

• DELIVERY : 10% OF PURCHASED EQUIPMENT = $€3,906,318 \times 0.1 = €390,632$

SUBTOTAL OF DELIVERED EQUIPMENT = $€3,906,318 + €390,632 = €4,296,950$

• EQUIPMENT INSTALLATION	0.47	= €2,019,567
• INSTRUMENTATION AND CONTROL	0.36	= €1,546,902
• PIPING	0.68	= €2,921,926
• ELECTRICAL SYSTEM	0.11	= €472,665
• BUILDINGS	0.18	= €773,451
• YARD IMPROVEMENT	0.10	= €429,695
• SERVICE FACILITIES	0.70	= €3,007,865

TOTAL DIRECT COST = €15,469,021

* INDIRECT COST IN EURO

• ENGINEERING AND SUPERVISION	0.33	= €1,417,994
• CONSTRUCTION EXPENSES	0.41	= €1,761,750
• LEGAL EXPENSES	0.04	= €171,878
• CONTRACTOR'S FEE	0.22	= €945,329
• CONTINGENCY	0.44	= €1,890,658

TOTAL INDIRECT COST = €6,187,609

• • NEW FIXED CAPITAL COST OF PLANT IN EURO
= €15,469,021 + €6,187,609
= €21,656,630

19
—
20

AVERAGE

Average Student Original Graded Assignment for Final Exam

24/30

CHEG 4304: Process Design & Analysis

1. $EAC = (\text{Capital Investment})(A/P, i, n) + \text{Yearly Operating Cost}$

$(A/P, i, n) = \frac{i(1+i)^n}{(1+i)^n - 1}$

Alternative	Equipment Life (yr)	Capital Cost (\$M)	Operating Cost (\$M/yr)
A	9	24	2.6
B	5	16	3.6
C	3	6	5.6

$EAC_A = (24,000,000) \frac{(0.12)(1.12)^9}{1.12^9 - 1} + 2.6M = \7.1 per year

$EAC_B = (16,000,000) \frac{(0.12)(1.12)^5}{1.12^5 - 1} + 3.6M = \8.4 per year

$EAC_C = (6,000,000) \frac{(0.12)(1.12)^3}{1.12^3 - 1} + 5.6M = \8.1 per year

Alternative A would be the best choice

10/10

Problem 2:

1. Given cost for 2006:

Reactor: 400 K

Distillation: 600 K

Separators: 250 K

Others: 150 K

Cost for 2021:

$$400 \left(\frac{610}{500} \right) = 488 \text{ K}$$

$$600 \left(\frac{610}{500} \right) = 732 \text{ K}$$

$$250 \left(\frac{610}{500} \right) = 305 \text{ K}$$

$$150 \left(\frac{610}{500} \right) = 183 \text{ K}$$

Find cost for 2021:

$$\text{Use eqn: } C_2 = C_1 \left(\frac{I_2}{I_1} \right)$$

* Given Index for 2021: 610

* From chart Index for 2006: 500

Total cost for 2006: 1.4 M

$$1.4 \left(\frac{610}{500} \right) = 1.708 \text{ M}$$

Total cost for 2021: 7.1 M

Indirect cost:

- Engineering & supervision
- Construction Expenses
- Legal Expenses
- Contractor's Fee
- contingency

Fluid:

$$0.33 = 0.421 \text{ M}$$

$$0.41 = 0.771 \text{ M}$$

$$0.04 = 0.075 \text{ M}$$

$$0.22 = 0.414 \text{ M}$$

$$0.44 = 0.828 \text{ M}$$

$$\boxed{\text{TIC} = 2.709 \text{ M}}$$

Direct Cost:

• Equipment Installation

Fluid:

$$0.47 = 0.884 \text{ M}$$

• Instrumentation & Control

$$0.36 = 0.677 \text{ M}$$

• Piping

$$0.68 = 1.279 \text{ M}$$

• Electrical System

$$0.11 = 0.207 \text{ M}$$

• Buildings

$$0.18 = 0.339 \text{ M}$$

• Yard Improvement

$$0.10 = 0.1881 \text{ M}$$

• Service Facilities:

$$0.70 = 1.317 \text{ M}$$

$$\text{TDC} = 6.772 \text{ M}$$

"Plant Design and Economics for Chemical Engineers":

- 10% purchased equipment = 1.708 M

$$1.708 (-10) = 0.1708 \text{ M}$$

- Subtotal delivered equipment = 1.708 M

$$1.708 \text{ M} + 0.1708 \text{ M} = 1.879 \text{ M}$$

- Current Fixed Cost = 6.772 M + 2.709 M

$$= \boxed{9.481 \text{ M}}$$

2. Calculate total capital investment in 2021 if the working capital is 20% of the fixed capital investment.

$$\text{Fixed capital} = 9.481 \text{ M}$$

$$\text{WC} = 9.481 \times 0.20 = 1.8962 \text{ M}$$

$$\text{TCI} = 9.481 \text{ M} + 1.8962 \text{ M} = \boxed{11.38 \text{ M}}$$

* convert to thousands to make calculation easier:

$$\begin{aligned} - \text{TCI} &= \$2049.6 \text{ K} \\ (c2) - \text{total fixed cost in 2021} &= \$1708 \text{ K} \end{aligned}$$

3. knowns:

- $n = 10$ years
- after tax = 10%
- salvage value = 15% (of fixed capital investment + 10% of working capital)
- annual cash flow = \$1 million per year
- salvage = $0.15(1708 \text{ K}) + 0.10(0.20)(1708 \text{ K}) = \290.36 K

a) NPV:

$$\begin{aligned} \text{NPV} &= -(\text{total capital investment}) + (\text{annual cash flow}) \\ &\quad (\text{P/A}, i, n) + \text{salvage value} (\text{P/F}, i, n) \\ &= -\$2049.6 \text{ K} + \$1000 \text{ K} (\text{P/A}, 10\%, 10) + \\ &\quad \$290.36 \text{ K} (\text{P/F}, 10\%, 10) \\ &= -\$2049.6 \text{ K} + \$1000 \text{ K} (6.1446) + 290.36 \text{ K} (0.3855) \end{aligned}$$

$$\boxed{\text{NPV} = \$4206.9 \text{ K}}$$

b) payback period:

$$\text{payback period} = \frac{\text{initial investment}}{\text{annual cash flow}} = \frac{\text{total capital invest.}}{\text{annual cash flow}}$$

$$= \frac{\$2049.6 \text{ K}}{\$1000 \text{ K}} = 2.0496 \approx 2$$

$$\boxed{\text{payback period} = 2 \text{ years}}$$

$$14/20$$

4. Discounted cash flow rate of return on investment for the plant:

$$\text{DCFRR} = [\text{lower discount rate from Table E10.3 in book}] + i(\text{interpolation factor})$$

Interpolation Factor (from Table E10.3):

$$X = \$4206.9 \text{ K} ; Y = \text{DCFRR} = ?$$

$$X_1 = \$17120 \text{ K} ; Y_1 = \text{discount rate} = 10\%$$

$$X_2 = \$770 \text{ K} ; Y_2 = \text{discount rate} = 12\%$$

$$\begin{aligned} \text{interpolation factor} &= \frac{(X - X_1)}{(X_2 - X_1)} = \frac{(\$4206.9 \text{ K} - \$17120 \text{ K})}{(\$770 \text{ K} - \$17120 \text{ K})} \\ &= 0.79 \end{aligned}$$

$$\text{DCFRR} = Y_2 + i(0.79)$$

$$\boxed{\text{DCFRR} = 10 + 1(0.79) = 10.79\%}$$

D) CRR is when $\text{NPV} = 0$

5. Derive fixed capital cost.

capital exponent value (n)

$$\frac{C_a}{C_b} = \left(\frac{A_a}{A_b} \right)^n \Rightarrow \log \left(\frac{C_a}{C_b} \right) = n \log \left(\frac{A_a}{A_b} \right)$$

$$n = \frac{\log \left(\frac{C_a}{C_b} \right)}{\log \left(\frac{A_a}{A_b} \right)}$$

for 100 gpm pump * $C_a = \$100K$ $A_a = ?$
* $C_b = \$125K$ $A_b = ?$

$$n = \frac{\log \left(\frac{100}{125} \right)}{\log \left(\frac{2}{3} \right)} = 0.55$$

$$n = 0.55$$

* cost of equipment @ triple capacity *:

Reactors $C_a = \$400K$; $A_a = 1$; $C_b = ?$;

$$n = 0.55 ; A_b = 3$$

$$C_b = \frac{C_a}{\left(\frac{A_a}{A_b} \right)^n} = \frac{\$400K}{\left(\frac{1}{3} \right)^{0.55}} = \$731.9K$$

* Distillation units in plant *:

- $C_a = \$600K$; $C_b = ?$; $A_a = 1$; $A_b = 3$; $n = 0.55$

$$C_b = \frac{\$600K}{\left(\frac{1}{3} \right)^{0.55}} = \$1097.9K$$

* separators in plant *:

- $C_a = \$250K$; $C_b = ?$; $A_a = 1$; $A_b = 3$; $n = 0.55$

$$C_b = \frac{\$250K}{\left(\frac{1}{3} \right)^{0.55}} = \$457.5K$$

* Other units in plant v:

$$- C_a = \$150K ; C_b = ? ; A_a = 1 ; A_b = 3 ; n = 0.55$$

$$C_a = \frac{\$150K}{\left(\frac{1}{3}\right)^{0.55}} = \$274.5K$$

$$100 \text{ gpm pump} \Rightarrow C = \$125K$$

* Total cost of fixed capital cost K : $\$2606.8K$

$$- 50\% \text{ Denmark markup} = \$2606.8K (1.5)$$

$$\begin{aligned} \text{+ Total cost of fixed capital cost in Denmark (\$USD) } K &= \\ &= \$4030.2K \end{aligned}$$

Total fixed capital cost in Denmark (pounds) = $3100K \text{ £}$

~~X~~

$$= \$4030.2 \mid \begin{array}{l} 1 (\text{£}) = 3100K \text{ £} \\ 1.30 (\text{USD } \$) \end{array}$$

BELOW AVERAGE

Below Average Student Original Graded Assignment on Final Exam

Name of Student: Xavier Williamson

20
30

NOTE: WORK MUST BE INDEPENDENT (INDIVIDUAL).

Problem 1: You are the process engineer in a plant that needs to select equipment for one of their units operations. The after-tax hurdle rate is 12% per annum. From the below three alternative choices which one would you recommend?

Alternative	Equipment Life (Yr)	Capital Cost (\$Million)	Operating Cost (\$Million)
A	9	24	2.6
B	5	16	3.6
C	3	6	5.6

Hint: Use Equivalent Annual Operating Cost (EAOC) method

Problem 2: As a chemical engineer with Bestdeal Company, Houston, TX you were part of the team that carried out a good estimate for all the major equipment for the production of a plant for the new product to be on stream in 2021. The cost of the major equipment carried out in the year 2006 are: Reactors- \$400K; Distillation Units - \$600K; Separators- \$250K, others - \$150K. Assume that the current chemical engineering cost index (CECI) in 2021 is 610:

- (1) Calculate the current fixed capital cost for the plant using the estimating cost software in "Plant Design and Economics for Chemical Engineers", 5th edition, by Peters, Timmerhaus and West. Show the details of your estimate by providing both the indirect and direct costs. (Hint: From your class text book, locate the CECI for the year 2006.)
- (2) Calculate the total capital investment in 2021 if the working capital is 20% of the fixed capital investment.
- (3) The plant has 10 years life and at the end of its life 15% of the original fixed capital investment is recovered as salvage value and 10% of the working capital is also recovered. Calculate (a) the NPV and (b) the payback period of the plant assume that the after-tax hurdle rate is 10% and the annual cash flow is \$1 million per year.
- (4) From question 3 above, calculate the discounted cash flow rate of return on investment for the plant.
- (5) If the plant is to be replicated in Denmark but with production capacity tripled due to a large demand, calculate the new fixed capital cost of the plant in euro (assume 1 Euro = \$1.30). Note that each item of the major equipment is 50% relatively more expensive in Denmark compare to US; that is for example in 2006, a reactor that cost \$1.00 in US cost a euro equivalent of \$1.50 in Denmark. And also one major 100 gpm pump equipment is to be added necessary to meet Denmark's market. The information on this particular equipment in 2006 are: Twice its capacity cost \$100K and triple its capacity cost \$125K. (Hint: Calculate the capacity exponent value that will help you to calculate the cost of the additional major equipment to meet Denmark's market. Then you update the cost of all the major equipment.)

1,

$$EAOC_A = 24,000,000 \left(\frac{0.12(1.12)^9}{1.12^9 - 1} \right) + 2,600,000 = \$7,104,293.33$$

$$EAOC_B = 16,000,000 \left(\frac{0.12(1.12)^5}{1.12^5 - 1} \right) + 3,600,000 = \$8,038,555.71$$

$$EAOC_C = 6,000,000 \left(\frac{0.12(1.12)^3}{1.12^3 - 1} \right) + 5,600,000 = \$8,098,093.88$$

I would recommend Alternative A because it is the lowest cost out of the 3 Alternatives.

10/10

2.

Cost of Major equipment (2006)

Reactors = \$400K

Distillation Units = \$600K

Separator = \$250K

Others = \$150K

CECI (2021): 610

CECI (2006): 500

Plant = \$1,400,000

1)

$$C_2 = C_1 \left(\frac{I_2}{I_1} \right) \quad \begin{matrix} I_1 = 500 \\ I_2 = 610 \end{matrix}$$

$$\rightarrow C_2 = \$1,400,000 \left(\frac{610}{500} \right) = \$1,708,000$$

$$\boxed{\text{Fixed capital cost} = \$1,708,000}$$

Equipment

$$\text{Direct cost} = 400000 \left(\frac{610}{500} \right) = \$488,000$$

$$600000 \left(\frac{610}{500} \right) = \$732,000$$

$$250000 \left(\frac{610}{500} \right) = \$305,000$$

$$150000 \left(\frac{610}{500} \right) = \$183,000$$

$$\underline{\$1,708,000 = \text{Fixed capital cost}}$$

2)

Total Capital Investment = working capital + fixed capital

$$= (0.2) (\$1,708,000) + (\$1,708,000)$$

$$= \$341,600 + \$1,708,000$$

$$\boxed{= \$2,049,600}$$

3)

10 years life

15% of original is salvaged

10% of working capital salvaged

$$\text{Salvage value} = 0.15 (\$1,708,000) + 0.10 (\$341,600) = \$290,360$$

a) $NPV = -(\text{total capital investment}) + \text{annual cash flow} (P/A, i, n) + \text{salvage value} (P/F, i, n)$

$= -\$2,049,600 + \$1,000,000 (P/A, 10\%, 10) + \$290,360 (P/F, 10\%, 10)$

$= -\$2,049,600 + \$1,000,000 (6.14) + \$290,360 (0.39)$

$= \$4,203,640$

2

b) $\text{payback period} = \frac{\text{total capital investment}}{\text{annual cash flow}} = \frac{\$2,049,600}{\$1,000,000} = 2.05 \approx 2 \text{ years}$

X

4) Discounted cash flow rate of return on investment

= lower discount rate + 1 (interpolation factor)

$X = \$4,203,640$ $Y = \text{DCFROR}$

$X_1 = \$17,120,000$ $Y_1 = @ 10\%$

$X_2 = \$770,000$ $Y_2 = @ 12\%$

$\text{Interpolation factor} = \frac{(\$4,203,640 - \$17,120,000)}{(\$770,000 - \$17,120,000)} = 0.79$

$\text{DCFROR} = Y_2 + 1(0.79)$

$= 10 + 1(0.79) = 10.79\%$

X

1

5)

$$\frac{C_a}{C_b} = \left(\frac{A_a}{A_b}\right)^n = \log\left(\frac{C_a}{C_b}\right) = n \log\left(\frac{A_a}{A_b}\right) \rightarrow n = \frac{\log\left(\frac{C_a}{C_b}\right)}{\log\left(\frac{A_a}{A_b}\right)}$$

$C_a = \$100,000$
 $C_b = \$125,000$
 $A_a = 2$
 $A_b = 3$

$$n = \frac{\log\left(\frac{100,000}{125,000}\right)}{\log\left(\frac{2}{3}\right)} = \boxed{0.55}$$

Reactors;

$C_a = \$400,000$
 $A_a = 1$
 $A_b = 3$
 $n = 0.55$
 $C_b = ?$

$$C_b = \frac{C_a}{\left(\frac{A_a}{A_b}\right)^n} \rightarrow \frac{400,000}{\left(\frac{1}{3}\right)^{0.55}} = \boxed{\$731,942}$$

Distillation units

$C_a = \$600,000$
 $A_a = 1$
 $A_b = 3$
 $n = 0.55$
 $C_b = ?$

$$C_b = \frac{C_a}{\left(\frac{A_a}{A_b}\right)^n} \rightarrow \frac{600,000}{\left(\frac{1}{3}\right)^{0.55}} = \boxed{\$1,097,913}$$

Separators

$C_a = \$250,000$
 $A_a = 1$
 $A_b = 3$
 $n = 0.55$
 $C_b = ?$

$$C_b = \frac{C_a}{\left(\frac{A_a}{A_b}\right)^n} \rightarrow \frac{250,000}{\left(\frac{1}{3}\right)^{0.55}} = \boxed{\$457,463}$$

Others

$C_a = \$150,000$
 $A_a = 1$
 $A_b = 3$
 $n = 0.55$
 $C_b = ?$

$$C_b = \frac{C_a}{\left(\frac{A_a}{A_b}\right)^n} \rightarrow \frac{150,000}{\left(\frac{1}{3}\right)^{0.55}} = \boxed{\$274,478}$$

Fixed Capital Cost = \$2,561,796

Fixed Capital Cost in Denmark = \$3,842,694

$$\text{Fixed Capital Cost in Denmark (Euros)} = \frac{\$3,842,694}{1.30} = \boxed{2,955,918 \text{ Euros}}$$

Equipment

10/20

-1

Don't mark calculations?
-6