CHEMICAL ENGINEERING 4L03

Advanced Laboratory Skills

Instructor: Prof. Charles-François de Lannoy (Dr. d)

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1. Course Outline

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1.1 Course Description

The course consists of a series of three 3-week laboratory projects in the areas of mass transfer, process control, biotechnology, polymer processing, and industrial-scale operations. Results from prescribed experiments as well as self-directed learning modules and/or techno-economic analyses will be presented through formal write-ups and one oral presentation. There will also be bi-weekly lectures for the first third of the course.

The instructor and university reserve the right to modify elements of the course during the term. The university may change the dates and deadlines for any or all courses in extreme circumstances. If either type of modification becomes necessary, reasonable notice and communication with the students will be given with explanation and the opportunity to comment on changes. It is the responsibility of the student to check their McMaster email and the course Avenue site weekly during the term and to note any changes.

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1.2 The P.R.O.C.E.S.S.

As some of you may already be aware, the department of Chemical Engineering has a storied history of education. In addition to teaching and learning, the department is proud of our graduates not only for their academic success, but their more intrinsic traits that make them respected members of the engineering community.

Recently, several high-ranking graduates from the McMaster Chemical Engineering Program employed in various industries (oil/gas, financials, *etc*.) were interviewed to ask what traits they look for when hiring for engineering positions. Using this information, the department would like to present to you the **PROCESS**: a code of conduct that we hope will guide our students throughout this program and their careers to come.

- **P**rofessionalism
- **R**esponsibility
- **O**wnership
- **C**uriosity
- **E**mpathy
- **S**elflessness
- **S**ervice

It is up to YOU to interpret these traits and apply them to your time at McMaster and your career as you see fit. These traits will not be assessed for grades but will be strongly encouraged throughout your time at McMaster. We hope that you identify with these character traits and what they mean to you, and that you **trust the process**.

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1.3 Course Objectives

The laboratory sessions, lectures, and review meetings are planned to:

1. Provide practical experiments that illustrate the fundamental ideas from prior chemical engineering courses
2. Give practice in realistic measurement and interpretation of data using statistical techniques
3. Act as an educational precursor to ChE 4C03 (engineering stats), ChE 4G03 (optimization), CivE 4V04 (wastewater treatment), ChE 4E03 (process control II), and ChE 4M03 (separations)
4. Give experience in analyzing relevant industrial scale equipment
5. Give practice in formulating questions in the form of scientific hypotheses and investigating these hypotheses using laboratory equipment
6. Give practice using the literature (textbooks, handbooks, journals, and vendor information)
7. Give practice with manual laboratory skills and laboratory equipment
8. Give first-hand experience in safety assessment of experimental work
9. Give practice in the preparation of formal written reports
10. Give practice in verbal technical discussions, both formal and informal
11. Give practice using technical communication and problem-solving skills

It is expected that the laboratory experiments and reports will be carried out in more depth and technical detail than in ChE 3L02. Problems will be more open-ended, and it will be necessary to formulate objectives that can be achieved using the provided equipment. The self-directed learning (SDL) component of the lab will be more significant in ChE 4L03, with more background preparation expected and formal hypotheses/experimental plans to be completed for each experiment.

1.4 Course Texts

REQUIRED – ChE 4L03 Custom Courseware (print at your own convenience)

***** Some special material for some experiments may be required (provided in-lab or on the Avenue site for the course).

For writing technical reports, please refer to Bliqc & Moretto "Technically-Write!" Prentice Hall. This text has been used previously for ChE 2G03 & 3L02 and copies are available in Thode library.

1.5 Course Organization:

	Day	Start Time	End Time	Room
Class	Tuesday and Friday	8:30 am	9:20 am	Hamilton Hall 109 (CNH 102)
Lab L01	Monday	1:30 pm	4:30 pm	JHE A106
Lab L02	Tuesday	1:30 pm	4:30 pm	JHE A106
Lab L03	Wednesday	1:30 pm	4:30 pm	JHE A106
Lab L04	Thursday	1:30 pm	4:30 pm	JHE A106
Lab L05	Friday	1:30 pm	4:30 pm	JHE A106

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1.6 Laboratory sessions

Students will work in groups of 3 to 5; each student will get experience in working on real equipment, analyzing and presenting data in a formal environment and working in groups. Students must be present at the start of each laboratory period.

Report guidelines are included in a separate document. Students must complete all tasks for the experimental period by the end of the lab session. No one will be permitted to stay in the laboratory past this time. With TA & Lab technician approval, students may be allowed to come in before the original start time of the lab. The TAs will be available in the lab throughout each lab session for questions. The instructor will be available for consultation by appointment. Permission of the course instructor will be required for changes in the schedule. Note that employment interviews are not an acceptable reason for rescheduling laboratory work. Students must attend all laboratory periods; exceptions are only allowed with a medical certificate or with the permission of the instructor. If two days are missed for the same lab cycle, the student will have to do another experiment during the next lab cycle with a different class time.

1.7 Lectures

Lecture periods are devoted to the development of experimental design and analysis skills applicable both to this course and any technical experimental setting. Lecture notes for these sessions are posted on Avenue to Learn for download. The lectures are designed such that they will be of benefit to improving your mark in this course and by progressing/solidifying translatable job skills. There will be several guest lecturers throughout the course. These are individuals with expertise in an area relating to one of the 6-7 experiments.

Table 1A tentative schedule of lecture topics is provided below (schedule subject to change):

Lecture 1	September 5	Course introduction: lab orientation, course structure, laboratory safety
Lecture 2	September 8	Error and Experimental Design
Lecture 3	September 12	Writing scientific reports: structure and strategies
Lecture 4	September 15	Guest Speaker: Dr. Catherine Clase, Hamilton Center for Kidney Research Faculty of Health Sciences, Medicine **Hemodialysis**: A medical story
Lecture 5	September 19	Design of Experiments (DOE) statistical optimization
Lecture 6	September 22	Guest Speaker Dr. Jake Nease, McMaster University Principles of **process control 1**
	September 26	NO CLASS
Lecture 7	September 29	Guest Speaker: Dr. Jake Nease, McMaster University Principles of **process control 2**
Lecture 8	October 3	Guest Speaker: Abhishek Premachandra, *McMaster University* Abdelrahman Awad Babiker, McMaster University

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		Advances in membrane technology for water and **wastewater** treatment
Lecture 9	October 6	Guest Speaker: Navid Noor, *McMaster University* **Electrocatalysis** for advances in carbon capture And utilization
	October 10	NO CLASS – Fall Break
	October 13	NO CLASS – Fall Break
Lecture 10	October 17	Guest Speaker: Dr. Yanan Cao, *Linde* Industrial **Gas** Separations: technology, operation strategy, and modeling
Lecture 11	October 20	Giving effective oral presentations

1.8 Course Assignments and Grading

The course will be graded based on the following scheme:

Lecture assignments (3)	5%
Guest Lecture Attendance and Participation	5%
Cycle 1 Laboratory Full Report (*Group*)	25%
Cycle 2 Laboratory R&D Report (*Individual*)	25%
Cycle 3 Laboratory Full Report (*Group*)	25%
Cycle 3 Laboratory Presentation (*Group*)	15%

Group work will be peer evaluated which will impact 50% of an individual's grade

Lab Report Marking Summary:

Lab preparation	5%
Preliminary reports (PR)	15%
Final Report (FR)	80%

Each student will do three laboratory experiments, each taking 3 weeks. The various experiments are listed at the end of this course outline. Unlike in 3L02, you can indicate some preference for which experiments you would like to do, which you have filled out in MS-*Forms*.

Lab Preparation (5%):

- Excel spreadsheet and or experimental tables ready for experimental data input
- Smooth transition into the laboratory experiments with minimal TA assistance
- Punctual and ready to start at the beginning of the laboratory scheduled time
- Demonstrated knowledge and understanding of all lab manual content

Preliminary Reports (15%)*:* A **preliminary report (PR)** must be submitted following the completion of the week 1 and week 2 laboratory sessions. These are to be e-mailed to the TA you had for the first week

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of your cycle AND uploaded to Avenue to Learn. For example, you have TA-4 in cycle 1-1 and TA-7 in cycle 1-2, then PR 1-1 and PR 1-2 both go to TA-4. The purpose of the PR is to oblige you to start the data analysis (rather than right before the formal report is due) and ensure you are on the right track in performing the experiment. PRs are to be submitted as a group, not individually. The PR component will account for 15% of the total mark assigned for the lab report.

PR format: (succinct, 2 page max.)

Clearly list the following:

a. Experiment title and date
b. Group members with respective student numbers & McMaster email addresses

Then in 500 words or less clearly state the following:

c. Objectives examined this day
d. Methods used (very brief – **only necessary if procedure deviated from manual procedure**)
e. Preliminary results presentation and discussion

Include raw data tables or figures as specified in the individual lab write-ups. Figures and/or tables should include appropriate statistical analysis; for example, y (flow rate) is linear in x (rotameter setting) as y = mx + b with a correlation coefficient of $R^2 = 0.98$, m = ... ± 95% Confidence Interval and b = ... ± 95% Confidence Interval. The corresponding 'preliminary discussion' could be as brief as: "Flow rate is linear in rotameter setting with an $R^2 = 0.98$". Use regression analysis; 'trendline' is not acceptable (except for drawing the line of curve on the figure). Data spreadsheets may be submitted as part of your raw data presentation. Reporting the R^2 is insufficient as an independent statistical metric; confidence intervals and/or Standard Error (SE) should always be used in accordance with an error propagation analysis. Interpreting ANOVA tables and using these statistical methods will be outlined in the in-class lectures.

PR is due by 11:59 pm two days following the laboratory session. You MUST upload the PR to Avenue to Learn (\Content \Assignments) and you must e-mail your PR to the TA that instructed you in week 1. An electronic copy of your graded PR will be returned to you before the beginning of the following lab session to help you with the preparation of your formal report.

Formal Reports (80%): The first and third lab will require a **full 12-page Final Report (FR).** The second lab will have an individual 5-page Final Reports (FRs) Results and Discussions (in a formal report style)

All reports are to be computer generated, i.e. no hand-written reports allowed. All reports are to be submitted to: **1) Avenue to Learn** AND **2) the lab TA you had in the first week of the cycle. Electronic copies of reports must be uploaded no later than 11:59 pm (before midnight) on the specified deadline date (see course calendar) to Avenue to Learn**. A standard deduction of 40% per day overdue applies; for example, a report awarded 75% but handed in 1 day late will receive a grade of 45%. The late penalty will be waived only on the presentation of a medical certificate. **MSAF will not apply for any group reports or the group presentation. All reports must be completed and handed in for a course credit. Failure to hand in any one laboratory report will result in automatic course failure.**

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Laboratory reports will be marked according to the guidelines for report writing and the detailed grading scheme included in this courseware package. Reports are expected to be clear and concise.

Cycle 1 Formal Report (FR) - Group: **A 12-page maximum writing limit** including Figures and Tables relevant for the report (not including Title Page, Table of Contents References, and Appendices), 1.5 line-spacing, 11 font Times New Roman, will be applied to final report in **cycle 1**.

Cycle 2 Formal Report (FR) - Individual: **A 5-page maximum writing limit** including Figures and Tables relevant for the report (not including Title Page, References, and Appendices), 1.5 line-spacing, 11 font Times New Roman, will be applied to final report in **cycle 2**.

Cycle 3 Formal Report (FR) - Group: **A 12-page maximum writing limit** including Figures and Tables relevant for the report (not including Title Page, Table of Contents References, and Appendices), 1.5 line-spacing, 11 font Times New Roman, will be applied to final report in **cycle 3**.

Reports exceeding these limits will be penalized, and excess pages will not be marked. The formal report will account for 80% of the total mark assigned to each experiment.

Students will have the opportunity to review their graded FR with the TA and/or the instructor. The student may sign out the report from the lab technician in JHE-A106 but **must return the graded report to Tim Stephens within seven days** – failure to do so will result in zero for that laboratory. Senate regulations require that the instructor must retain the laboratories. These marks are tentative and may be raised or lowered by the instructor to account for differences in the TAs grading styles.

Lab Report Schedule:

Cycle 1: (*Group report*) formal lab report contains a **full lab report** (Title Page, Table of Contents, Abstract, Introduction, Materials and Methods, Results, Discussion, Conclusion, References, Appendices). **Each group** must submit a **max 12-page** formal lab report. This page limit excludes, title page, table of contents, list of symbols, references, and appendices.

Cycle 2: (*Individual report*) formal lab report will only contain **Results and Discussion** sections. Appendices and References must be included. **Each student** must submit a **max 5-page** formal lab report

Cycle 3: (*Group report and Final group presentation*) formal lab report will only contain **full lab report** (Title Page, Table of Contents, Abstract, Introduction, Materials and Methods, Results, Discussion, Conclusion, References, Appendices). **Each group** must submit a **max 12-page** formal lab report. This page limit excludes, title page, table of contents, list of symbols, references, and appendices.

Peer Evaluations:

Major group work (final reports and presentations) will be peer evaluated to confirm that effort was equally distributed across the group. Only submit a peer evaluation form if you feel that there was a gross discrepancy in the effort and quality between your group members. The Peer evaluation form can be found on A2L

Lab Schedule:

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Sept 11 – 15 Lab cycle 1-1

Sept 18 – 22 Lab cycle 1-2

Sept 25 – 29 Lab cycle 1-3

Oct 2 – 6 Lab cycle 2-1

Oct 9 – 13 Midterm Recess

Oct 16 – 20 Lab cycle 2-2

Oct 23 – 27 Lab cycle 2-3

Oct 30 – Nov 3 Lab cycle 3-1

Nov 6 – 10 Lab cycle 3-2

Nov 13 – 17 Lab cycle 3-3

Presentations

Nov 27 – Dec 6

Laboratory Presentation:
A 20-minute presentation followed by questions by Prof. de Lannoy, Tim Stephens, and any audience members, will be conducted in groups on the results of the third labs starting in the second week after the end of cycle 3. The group presentation will be followed by an anonymous group evaluation. The presentation (in pdf format) must be e-mailed to Prof. de Lannoy and Tim Stephens **at least 2 days prior** to the presentation and the group evaluations must be e-mailed to Prof. de Lannoy no later than **2 days after** the presentation. A schedule for presentations will be posted on Avenue to Learn closer to the date. The group presentation mark may be adjusted for individual students in the group according to each student's performance during the presentation. The presentation will be marked according to the detailed grading scheme included in this courseware package and the guidelines to be discussed in the lecture period. The presentation will account for 15% of the final grade assigned in the course. The average score of the group evaluations will scale each student's final presentation grade.

Lecture assignments: Assignments will be due no later than 11:59 pm on the day it is due submitted through Avenue to Learn. Late assignments will NOT be accepted. Excused lateness must be worked out with the instructors **before** the assignment is due, or submit a McMaster Student Absence Form (MSAF). A total of two assignments worth 5% will cover topics that are general to the course material and not a specific experiment. A valid MSAF, will allow an extension of up to 5 days on the assignment due date.

Final grades will be converted to the 12-point scale using the Senate recommended conversion scale.

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A schedule indicating all key laboratory, lecture, and meeting slots relevant for each lab section is included in this course package. Students will NOT be permitted to switch lab sections after completing the first laboratory session.

Centre for Student Development:

"Students with disabilities can receive accommodations to assist them in the completion of their assignments and exams. Please contact the Centre for Student Development for advice and for arranging assistance." Further info at: ***http://csd.mcmaster.ca***

1.9 Senate and The Faculty of Engineering Policies:

"The Faculty of Engineering is concerned with ensuring an environment that is free of all adverse discrimination. If there is a problem, that cannot be resolved by discussion among the persons concerned, individuals are reminded that they should contact the Department Chair, the Sexual Harassment Officer or the Human Rights Consultant, as soon as possible."

1.10 Plagiarism and Academic Dishonesty

Plagiarism is a serious issue to you as an academic and a future professional, and will be treated as such in this course should it occur. You will be using Avenue to Learn which is Turnitin.com enabled to verify the originality of your laboratory reports throughout the course. Please note the following for Turnitin.com:

1. An originality report will be generated and reviewed by the instructor.
2. Generation of the originality report may not be available until after the report is due.
3. As several years of reports on similar laboratories are in the database, it is inevitable that some identical phrases or expressions may occur between your report and previous reports – this is to be expected. We are not looking for a particular percentage of 'originality' but rather looking through the full originality report to confirm the laboratory report is your original work.

Please refer to the university policy on academic dishonesty (reproduced below) for the definition of plagiarism as it pertains to this course: Please note that plagiarism cases *will be reported* and the procedures outlined below *will be followed* if an issue were to occur.

"You are expected to exhibit honesty and use ethical behavior in all aspects of the learning process. Academic credentials you earn are rooted in principles of honesty and academic integrity."

"Academic dishonesty is to knowingly act or fail to act in a way that results or could result in unearned academic credit or advantage. This behavior can result in serious consequences, e.g. the grade of zero on an assignment, loss of credit with a notation on the transcript (notation reads: "Grade of F assigned for academic dishonesty"), and/or suspension or expulsion from the university."

"It is your responsibility to understand what constitutes academic dishonesty. For information, the various types of

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academic dishonesty please refer to the Academic Integrity Policy, located at http://www.mcmaster.ca/academicintegrity"

The following illustrates only three forms of academic dishonesty:

1. *Plagiarism, e.g. the submission of work that is not one's own or for which other credit has been obtained. **
2. *Improper collaboration in group work. **
3. *Copying or using unauthorized aids in tests and examinations. **

*In particular, in this course, copying of previously submitted laboratory reports or data is considered to be an extreme case of academic dishonesty/plagiarism.
In this course, we will be using Turnitin.com and Avenue to Learn. Students should be aware that, when they access the electronic components of this course, private information such as first and last names, user names for the McMaster e-mail accounts, and program affiliation may become apparent to all other students in the same course. The available information is dependent on the technology used. Continuation in this course will be deemed consent to this disclosure. If you have any questions or concerns about such disclosure, please discuss this with the course instructor.

2. Laboratory Safety and Safety Checklist

An overview of the principles of laboratory safety will be given in the first lecture. You are responsible to familiarize yourself with the experiment prior to entering the laboratory to gain a preliminary understanding of the key safety issues associated with each experiment. On the first day of an experiment, your instructor or teaching assistant will be available to answer any questions that you may have about the experiment to be done. It is important at this time that you fully understand any hazardous features of the experiment. For example:

a) Pressure, vacuum experiments
- Correct operation and handling of gas cylinders
- Need for eye protection with glassware
- Pressure limitations with large vessels
- Pressure limitations of tubing

b) Acids and bases
- Corrosion and burns
- Heat effects (e.g. sulfuric acid and water)
- Gloves required?

c) Organic liquids
- Volatility and toxicity (fume hood or other special precautions needed?)
- Flammability – location of the nearest fire extinguisher

d) Electrical equipment
- Check for frayed wires
- Avoid wires trailing on the floor
- Keep wires away from water

e) Large scale equipment
- Safe use of ladders

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Safe access to control points
Correct start-up procedures

f) Shut down of equipment

Ensure that all equipment is completely shut down in a safe sequence at the end of each lab period. Do not leave dangerous materials lying in the open. Ensure that valuable small items (stopwatches, pipettors) are not left in the open.

No food, drink, or smoking is permitted in the laboratory areas. Coats and bags must be left in lockers or safely out of the way. Protective eyewear must be worn – no exceptions.

Safety infractions will normally be dealt with as follows:

- First infraction –oral warning
- Second infraction – written warning
- Third infraction – failure on that laboratory
- Fourth infraction – withdraw and course failure

This order may not be followed depending on the seriousness of the student's action and will be left at the discretion of the course instructor.

In case of emergency:

Dial 88 from a campus phone
Dial (+1) 905-522-4135 from a cell phone (security services direct)

In case of fire, smoke or gas:

1. Pull the fire alarm
2. Dial 88 or 905-522-4135
3. Leave the building

If the fire alarm sounds:

1. Leave the building
2. Do not re-enter the building until the fire department or security approves

Familiarize yourself with the location of the nearest fire extinguisher, fire blanket, safety shower and eye wash station.

REMAIN CALM

Prior to each experiment, you will have to complete the safety checklist (distributed in the lab), as shown on the following sheet. Read the protocols for your lab carefully prior to entering the lab to become familiar with all the hazards of the experiment and assist in completing this safety form.

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2.1 ChE 4L03 SAFETY CONSIDERATIONS*

Name and Student No.: _____ Instructor: _____ Date: _____

(To be completed in the laboratory before experimental work can begin on a new project.)

Laboratory Equipment:

Fill in the key safety concerns and actions to be taken with respect to potential hazards in the following areas:

a) Pressure/Vacuum:

b) Chemicals:

c) Electrical Equipment:

d) Large-scale Equipment:

e) Start-up and Shut-down of Equipment:

f) Other:

If you perceive that you may be taking an unsafe action or are in an unsafe situation, inform the teaching assistant or instructor.

I have received instruction in and understand the safety issues associated with this experiment.

Signature: _____ Date: _____

*Available in the lab prior to each new laboratory.

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3. Report Grade Forms

3.1 Preliminary Report Grade Form

Lab Period (Mon, Tues, Wed, Thu. Fri; 1, 2, or 3) ____

Experiment Title: _____

TA Name: _____

Objectives (and additional Methods if relevant)	___/2	Objectives of the week were clearly and concisely stated in their own words, not copy-pasted from the lab manual. Where appropriate additional methods not covered in the lab manual were clearly described
Results	___ / 2	Results were presented in figures and/or tables. Figure and/or tables included appropriate statistical analysis; for example, y (flow rate) is linear in x (rotameter setting) as y = mx + b with a correlation coefficient of R^2 = 0.98, m = ... ± 95% Confidence Interval and b = ... ± 95% Confidence Interval. Figures should follow recommendations from class on organization, simplicity, axes, units on axes, data points, etc.
Discussion	____/ 2	Preliminary discussion was accurate, clear, and concise
Statistics	___ / 2	confidence intervals and/or Standard Error (SE) were used in accordance with an error propagation analysis
Data	___ / 2	all *relevant* data was included in the report

REPORT TOTAL	___ / 10

Late Submission Penalty (# days * 40% each)	
TOTAL	___ / 10

Comments (can extend to additional pages):

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3.2 Individual Final Report Grade Form

Lab Period (Mon, Tues, Wed, Thu. Fri; 1, 2, or 3) ____ Student Name: _____

ID# _____

Experiment Title: _____

TA Name: _____

Results	___ / 30	all relevant graphs or tables included, clear, and properly formatted; figures or tables connected with explanatory text; main findings and trends of experiment identified (with statistical analysis as required)
Discussion	/ 35	data properly analyzed and interpreted relative to theory and experimental objectives; experimental design critiqued; sources of error analyzed; SDL rationale and results discussed in context of other results; recommendations made for future experiments
References	___ / 3	Minimum 4 references; properly formatted and cited in text
Appendices	___ / 3	all relevant data included; relevant statistical analyses performed
Spelling, Grammar, Style	___ / 6	correct sentence and paragraph structure; proper spelling Appropriate scientific writing style
Formatting	___ / 3	proper report length, formatting, and page numbering; table of contents properly formatted title page properly formatted; group report mentions contribution of members

REPORT TOTAL	___ / 80

Lab Preparation	___ / 5
Preliminary Reports	___ / 15

Late Submission Penalty (# days * 40% each)	
Missed Lab Penalty (# labs * 10% each)	
TOTAL	___ / 100

Comments (can extend to additional pages):

PROCEDURES to be followed with reports and forms: After the TA and instructor have graded the report, the student is given 1 copy of the report form and comments, the TA keeps 1 copy and the instructor also receives a copy. The laboratories reports are kept on file by the lab technician for two years, as required by Senate regulations.

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3.3 Group Final Report Grade Form

Lab Period (Mon, Tues, Wed, Thu, Fri; 1, 2, or 3): ____ Student Name: _____
Student ID# _____

Experiment Title: _____
TA Name: _____

Abstract	___ / 6	technically accurate; correct length and structure; clear statement of major problem, objective, approach, result, and conclusion of experiment
Introduction	___ / 8	clear statement of problem included; background material and theory outlined; specific objectives of experiment stated
Experimental	___ / 8	Apparatus and chemicals described; experimental procedures cited or described; specific experiments performed listed; safety issues highlighted
Results	___ / 14	all relevant graphs or tables included, clear, and properly formatted; figures or tables connected with explanatory text; main findings and trends of experiment identified (with statistical analysis as required)
Discussion	/ 20	data properly analyzed and interpreted relative to theory and experimental objectives; experimental design critiqued; sources of error analyzed; SDL rationale and results discussed in context of other results; recommendations made for future experiments
Conclusions	___ /6	correct length; correct format; state key outcomes and significance of results toward addressing the experimental objectives; no new information
References	___ / 3	Minimum 4 references; properly formatted and cited in text
Appendices	___ / 6	all relevant data included; relevant statistical analyses performed
Spelling, Grammar, Style	___ / 6	correct sentence and paragraph structure; proper spelling Appropriate scientific writing style
Formatting	___ / 3	proper report length, formatting, and page numbering; table of contents properly formatted title page properly formatted; group report mentions contribution of members

REPORT TOTAL	___ / 80

Lab Preparation	___ / 5
Preliminary Reports	___ / 15

Late Submission Penalty (# days * 40% each)	
Missed Lab Penalty (# labs * 10% each)	
TOTAL	___ / 100

Comments (can extend to additional pages):

PROCEDURES to be followed with reports and forms: After the TA and instructor have graded the report, the student is given 1 copy of the report form and comments, the TA keeps 1 copy and the instructor also receives a copy. The laboratories reports are kept on file by the lab technician for two years, as required by Senate regulations.

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4. Presentation Grade Form

Lab Period (Mon, Tues, Wed, Thu, Fri) _____

Member Names: 1) _____

2) _____

3) _____

4) _____

Experiment Title: _____

CONTENT

Introduction	___ / 5	clear statement of problem included; background material and theory *briefly* outlined; specific objectives of experiment stated
Experimental	___ / 3	apparatus, chemicals, and experimental procedures outlined; key safety issues highlighted
Results and Discussion	___ / 12	main findings and trends of experiment identified; key graphs or tables presented clearly and properly formatted; data properly interpreted relative to theory and experimental objectives; sources of error analyzed; recommendations made for future experiments
Conclusions	___ / 3	key outcomes and significance of results toward addressing the experimental objectives stated; no new information
Scope	___ / 3	key 2-3 points highlighted; proper amount of data presented
Questions	___ / 4	clear and correct responses to questions; good technique used
Content Total	____ / 30	(for all group members)

STYLE

Organization	___ / 8	logical order; clear story told during the presentation; correct timing; all members participate in presentation equally
Slides	___ / 6	clear; graphs and text large enough to read; not too much text per slide
Technique	___ / 6 (#1) ___ / 6 (#2) ___ / 6 (#3) ___ / 6 (#4)	eye contact maintained with audience; professional manner and approach; voice projected to audience

TOTAL (Content + Style Mark)	____ / 50 ____ / 50 ____ / 50 ____ / 50	(Group Member #1) (Group Member #2) (Group Member #3) (Group Member #4)

Comments (can extend to additional pages**):**

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